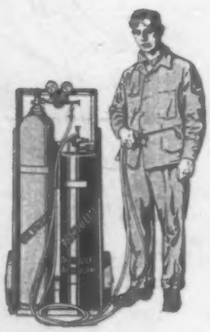
The Welding Engineer

Vol. II. Chicago 608 S. Dearborn St. SEPTEMBER, 1917 $2.00 per year in U. $2.50 per year abroad No. 9

Prest-O-Lite

Acetylene Service

Offers Real Assistance to Users of Oxy-Acetylene Welding



WE want everyone, who is interested in oxy-acetylene welding and cutting, to regard Prest-O-Lite Service as a big, helpful factor in the successful application of this remarkable process.

Many wonderful, profitable uses of welding—in metal manufacturing, construction and repair work—have led to its almost universal adoption in many of America's biggest industries.

Oxy-acetylene welding is perhaps the biggest, livest and most intensely interesting topic now before the metal working industries.

To those engaged in welding, and who desire practical information of real value, we will gladly mail, free of charge, our Welding Instruction Book, and supplement this book with such bulletins on special welding jobs and other data we may issue from time to time.

Prest-O-Lite engineers have been among the pioneers in welding research. They have collected and selected an immense fund of real welding data. This information is available to ***you.***

Write us for advice and data on welding or cutting problems you may have.

The Prest-O-Lite Co., Inc.

U. S. Main Office and Factory, 851 Speedway, Indianapolis, Ind.
Canadian General Office, Dept. B. 1, Toronto, Ontario

59 Branches and Charging Plants in Principal Industrial Centers

World's Largest Makers of Dissolved Acetylene

The largest makers of Oxy-Acetylene Welding and Cutting Equipment and Supplies in the World

Oxweld Equipment includes Acetylene Generators, Welding and Cutting Blow Pipes, Regulators and Supplies—everything needed for all requirements—complete installations for the most extensive manufacturing and repair operations to portable units for emergency and field use. Because of the scientific accuracy and exactness of design—high quality materials and the mechanical perfection of construction and workmanship, **OXWELD EQUIPMENT** will produce the most efficient and economical results in welding and cutting operations of every character.

Oxweld Supplies are made up in accordance with the formulae of our metallurgists—tested by analysis in our laboratory and their merits tested out and proven by our expert welders in actual shop practice. We guarantee **OXWELD SUPPLIES,** when used by competent welders, to produce better results than any others known to the art today.

Our knowledge and experience, as the largest makers of welding and cutting equipment in the world, are always at the service of every purchaser and prospective purchaser of **OXWELD APPARATUS,** to determine the most economical and efficient applications of the **PROCESS** to the manufacturing or repair problems at hand.

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The Welder's Delight—Made of fibre—an absolute Non-conductor of Heat. Light and durable.

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For PREHEATING in Connection with Your Welding Torch

Cut down the cost of Welding more than 50% and turn out Better Work

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BROOKLYN, N. Y.

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R.eceive no refusals

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Virtually every known application of
Incomparable Oxy-Acetylene Welding and
Cutting Equipment, which means
Economy and Efficiency.

Oxweld Railroad Service Co.

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Exceptionally durable construction of torches insures long, satisfactory service. Regulators dependable and free from valve, diaphragm and gauge troubles.

Ask for Catalogue No. 35.

The Alexander Milburn Company

Baltimore, Maryland

Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

ACETYLENE (Compressed in Cylinders)
Commercial Acetylene Welding Co.
The Prest-O-Lite Co., Inc.
Universal Oxygen Co.

ACETYLENE CYLINDERS

ACETYLENE GENERATORS
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Davis-Bournonville Co.
The Harris Calorific Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
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ALUMINUM FILLER RODS
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Hauck Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Mach. Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

ALUMINUM FLUX
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Bermo Supply Co.
Davis-Bournonville Co.
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Hauck Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

ALUMINUM SOLDER
Vulcan Process Co.

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ASBESTOS GLOVES
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ASBESTOS SHEET PAPER
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Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Buffalo Dental Mfg. Co.
Hauck Mfg. Co.
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Vulcan Process Co.

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The Welding Engineer
P. F. Willis.

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The Imperial Brass Mfg. Co.
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Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
Universal Oxygen Co.
Vulcan Process Co.

BRASS SPELTER WIRE
Universal Oxygen Co.
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United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Union Carbide Sales Co.

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CARBO-HYDROGEN
Carbo-Hydrogen Co. of America

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Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
Messer Mfg. Co.
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The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Mach. Co.
Universal Oxygen Co.
Vulcan Process Co.

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The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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H. G. Doran.

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Vulcan Process Co.

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Davis-Bournonville Co.
Hauck Mfg. Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
Steel Sales Corp.
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Bierman-Everett Fdy. Co.
Davis-Bournonville Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
Steel Sales Corp.
Vulcan Process Co.
United States Welding Co.
Universal Oxygen Co.

FILLER RODS (Vanadium Steel)
American Welding Co.
Bermo Supply Co.
Bierman-Everett Fdy. Co.
Davis-Bournonville Co.
Hauck Mfg. Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Steel Sales Corp.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

FIREPROOF PLASTIC
Bermo Supply Co.

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Westinghouse Electric & Mfg. Co.

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Hauck Mfg. Co.
Universal Oxygen Co.

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Hauck Mfg. Co.
The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Machine Co.

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Universal Oxygen Co.
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Vulcan Process Co.

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F. A. Hardy & Co.
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Buffalo Dental Mfg. Co.
K-G Welding & Cutting Co.
Superior Oxy-Acetylene Machine Co.
Vulcan Process Co.

The Growth of Oxy-Acetylene Welding and Cutting and the Increasing Demand for Davis-Bournonville Apparatus

A Year Ago we said—

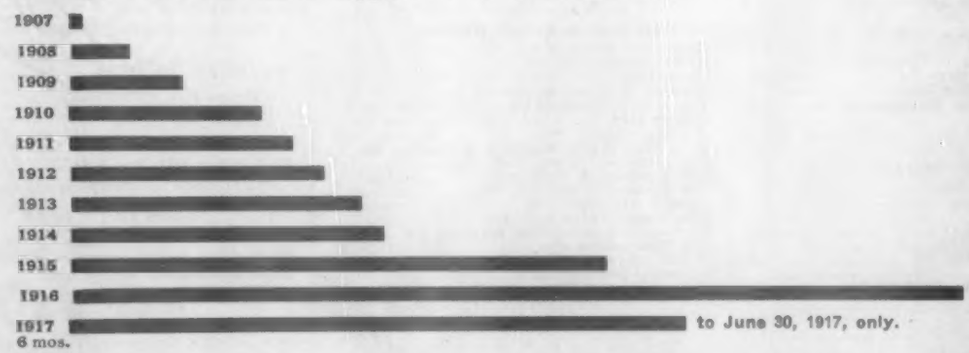
"The growth of Oxy-Acetylene Welding and Cutting in the United States is shown by the increasing use of Davis-Bournonville apparatus, which is inseparably associated with the development and success of the oxy-acetylene industry in this country.

"Ten years ago the process was unknown in the United States. Today it forms one of the great industries of the country, with its requirements for acetylene, oxygen and efficient apparatus.

"The Davis-Bournonville Company obtained the United States patents for the independent positive-pressure type of welding torch (mixing the gases in an interchangeable tip or nozzle) in 1906—basic principles which have been retained in the D-B torch because of their proven superiority through ten years of development, improvement and the most successful operation.

"There is more Davis-Bournonville welding and cutting apparatus in successful use in the United States than of any other make, and the prominent concerns which have established the greatest success with this process have large installations of D-B apparatus, with from ten to one hundred or more torch units, and from one to six of the largest acetylene generators."

Today—The increasing use of the oxy-acetylene process for welding and cutting and of Davis-Bournonville apparatus are parallel and are graphically shown by the sales of "Davis Apparatus" as charted below:



"Davis Apparatus" Leads the World in Range, Efficiency and Number of Successful Users. Write for bulletins and information showing why it is used by the largest steel mills, foundries, ship-yards, locomotive and car builders, U. S. Navy Yards and government works, mines, sheet metal working factories, tube and barrel welders, scrap yards, and in hundreds of small repair shops and garages.

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BOSTON	CLEVELAND		DETROIT	SAN FRANCISCO
PHILADELPHIA	CINCINNATI		ST. LOUIS	TORONTO, ONT. (Carter Welding Co.)

OIL BURNERS (Preheating)
Alger Supply Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Mach. Co.
Vulcan Process Co.

OXYGEN (Compressed in Cylinders)
Burdett Oxygen Co.
The Linde Air Products Co.
Swift & Co.
Universal Oxygen Co.
Vulcan Process Co.

OXYGEN CYLINDERS

PIPE WELDING
Goldschmitt Thermit Co.

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Chicago Architectural Photographing Co., (Specialists in photographs relating to the welding industry)

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PRESSURE GAUGES
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The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
U. S. Gauge Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

RAILROADS—Special Service for
Oxweld Railroad Service Co.

REGULATING VALVES (Acetylene)
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The Bastian-Blessing Co.
Bermo Supply Co.
Davis-Bournonville Co.
Hauck Mfg. Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
The Prest-O-Lite Co., Inc.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

REGULATING VALVES (Carbo-Hydrogen)
Carbo-Hydrogen Co. of America

REGULATING VALVES (Hydrogen)
American Welding Co.
The Bastian-Blessing Co.
Bermo Supply Co.
The Prest-O-Lite Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Superior Oxy-Acetylene Machine Co.
Universal Oxygen Co.
Vulcan Process Co.

REGULATING VALVES (Oxygen)
The Bastian-Blessing Co.
American Welding Co.
Bermo Supply Co.
Davis-Bournonville Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

SCHOOLS OF WELDING

SEAM WELDERS (Electric)
General Electric Co.
Westinghouse Electric & Mfg. Co.

SEAM WELDERS (Electric Resistance)
Thomson Electric Welding Co.

SPOT WELDERS (Electric Resistance)
Thomson Electric Welding Co.

TANK CONNECTIONS (Oxygen and Acetylene Adaptors)
Superior Oxy-Acetylene Machine Co.

THERMALENE-GAS
The Thermalene Co.

THERMIT WELDING
Goldschmidt-Thermit Co.

TORCHES (Carbo-Hydrogen)
Carbo-Hydrogen Co. of America

TORCHES (Gasoline and Kerosene Preheating)
American Welding Co.
Alger Supply Co.
Buffalo Dental Mfg. Co.
General Welding & Eq. Co.
The Imperial Brass Mfg. Co.
Hauck Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Westinghouse Electric & Mfg. Co.
Vulcan Process Co.

TORCHES (Oxy-Acetylene Cutting)
American Welding Co.
Bermo Supply Co.
Davis-Bournonville Co.
General Welding & Eq. Co.
The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
Messer Mfg. Co.
Welding Supply Co.
K-G Welding & Cutting Co.
The Alexander Milburn Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Machine Co.
The Thermalene Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

TORCHES (Oxy-Acetylene Welding)
American Welding Co.
Bermo Supply Co.
Davis-Bournonville Co.
General Welding & Eq. Co.
The Harris Calorific Co.
Messer Mfg. Co.
Welding Supply Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
The Alexander Milburn Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Machine Co.
The Thermalene Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

TORCHES (Oxy-Hydrogen Cutting)
American Welding Co.
Bermo Supply Co.
Davis-Bournonville Co.
Messer & Co.
Welding Supply Co.
General Welding & Eq. Co.
The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Alexander Milburn Co.
The Imperial Brass Mfg. Co.
Vulcan Process Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
Universal Oxygen Co.

TORCHES (Oxy-Hydrogen Welding)
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Bermo Supply Co.
Messer Mfg. Co.
Welding Supply Co.
Buffalo Dental Mfg. Co.
Davis-Bournonville Co.
Vulcan Process Co.
General Welding & Eq. Co.
The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
The Alexander Milburn Co.
Oxweld Acetylene Co.
United States Welding Co.
Universal Oxygen Co.

TORCHES (Special to Order)
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The Harris Calorific Co.
Superior Oxy-Acetylene Machine Co.
Vulcan Process Co.

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American Welding Co.
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M. Desmond Mfg. Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

VALVES (For Oxygen Cylinders)
The Bastian-Blessing Co.
Universal Oxygen Co.
Vulcan Process Co.

WELDING (Electric Resistance-Custom Work)
Thomson Electric Welding Co.

WELDERS' GOGGLES
Chicago Eye Shield Co.
F. A. Hardy Co.
Vulcan Process Co.

WELDING (Oxygen for)
The Linde Air Products Co.
Universal Oxygen Co.
Vulcan Process Co.

WELDING RODS
Bierman-Everett Fdy. Co.
Vulcan Process Co.

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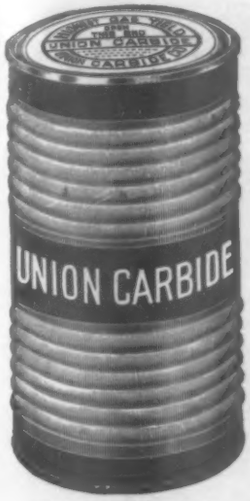

Packed in Blue and Gray Drums

Union Carbide Sales Company

New York City, 42nd St. Building — Chicago, Ill., Peoples Gas Building — San Francisco, Cal., Kohl Building

SOLE DISTRIBUTORS OF

UNION CARBIDE

"World's Best Quality—Highest Gas Yield"

For Oxy-Acetylene Welding Plants

Contractors' Flare Lights, Torches and Private and Municipal Lighting Plants

"Union Carbide" is packed in 100-lb. blue and gray drums marked conspicuously, "UNION CARBIDE."

The following sizes are carried in stock in 100-lb. drums:

3½ x 2 in. —a large size.

2 x ½ in. —a medium size.

1¼ x ⅜ in. —an intermediate size.

¼ x 1/12 in. —finely crushed size.

Union Carbide in the Generator sizes above listed will be shipped direct to consumers from a **Union Carbide Sales Co.** warehouse at any one of the following points where large stocks are kept on hand:

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Mobile—262-268 S. Water St.
Montgomery—114 N. Perry St.
ARIZONA
Phoenix—42 S. Central Ave.
ARKANSAS
Fort Smith—109-123 So. Ninth St.
CALIFORNIA
Eureka—109 Second St.
Fresno—922 H St.
Los Angeles—639 Gibbon St.
Sacramento—1523-31 Front St.
San Diego—326-336 Fifth St.
San Francisco—Kohl Building.
COLORADO
Denver—Nineteenth and Wazee Sts.
Victor—Third and Diamond Sts.
CONNECTICUT
Hartford—877 Main St.
DISTRICT OF COLUMBIA
Washington—Maryland Ave. and 9th St., S. W.
FLORIDA
Jacksonville—106 E. Forsyth St.
Tampa—418 Tampa St.
GEORGIA
Atlanta—Cor. Haynes and Rhodes Sts., P. O. Box 1594.
Savannah—Ogeechee Canal, South of Bay St., P. O. Box 78.
ILLINOIS
Chicago—Peoples Gas Bldg., Michigan Blvd.
Decatur—133-147 W. Williams St.
East St. Louis—600 Walnut Ave.
Peoria—721-731 So. Washington St.
Marion—315 S. Granite St., Box 747.
Monmouth—621 S. First St.
Quincy—222 S. Eighth St.
Streator—702 East Elm St.
INDIANA
Evansville—1601 Illinois St.
Indianapolis—110-112 S. Alabama St.
Terre Haute—921 Wabash Ave.
IOWA
Des Moines—117-119 Fifth St.
Dubuque—8th and Washington Sts.
Ottumwa—207-9-11 S. Washington St.
Sioux City—925 Fourth St., P. O. Box 296.
KANSAS
Pittsburg—109 W. Third St.
Salina—154 So. 5th St.
Wichita—721 Beacon Building.
KENTUCKY
Louisville—126 E. Main St.
Middlesboro—
LOUISIANA
New Orleans—819-21 Julia St.
MAINE
Portland—202 Commercial St.
MARYLAND
Baltimore—19 E. Lombard St.
Cumberland—1 N. Liberty St.
Salisbury—Opp. Fulton Station.
MASSACHUSETTS
Boston—(See Cambridge "A.")
Cambridge—241 Albany St.
Springfield—Napier St.
MICHIGAN
Detroit—3rd and Holden Aves.
Grand Rapids—500 Shawmut Ave., N. W.
Hancock—First National Bank Bldg.
Iron Mountain—215 E. A St.
Jackson—172 South Water St.
Saginaw—1830 No. Michigan Ave.
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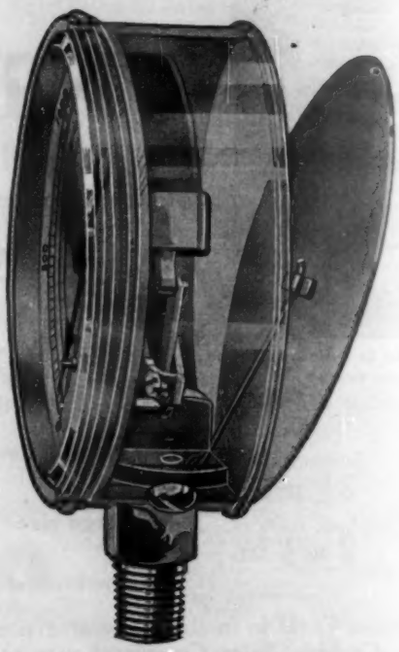

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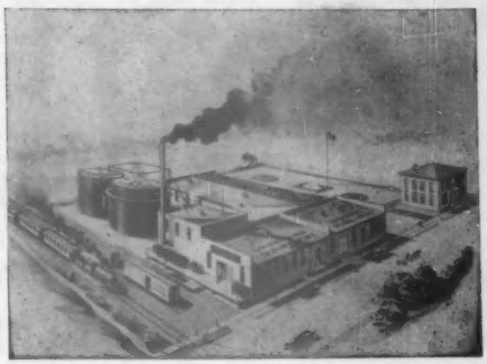

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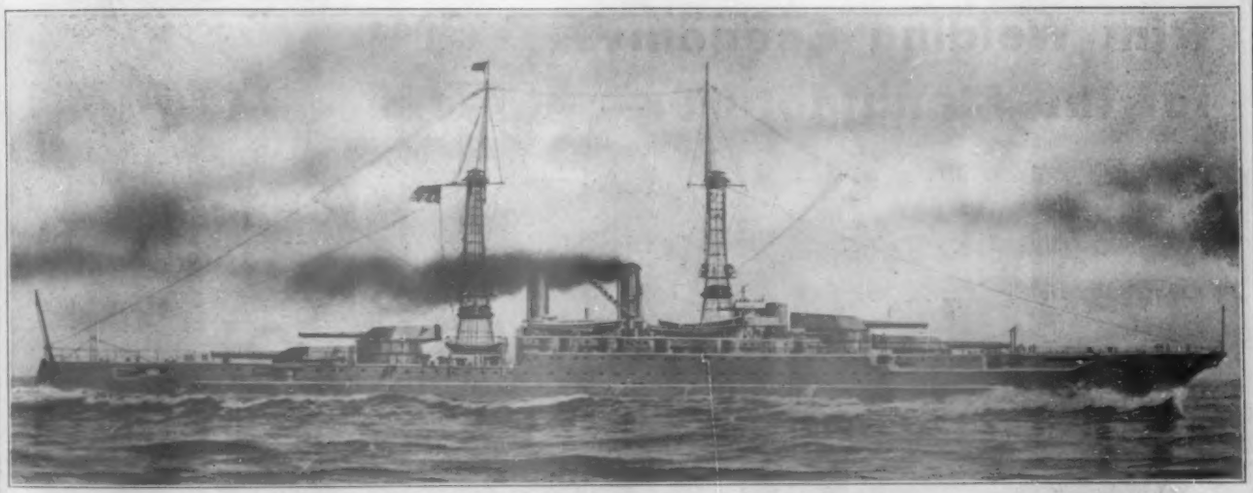

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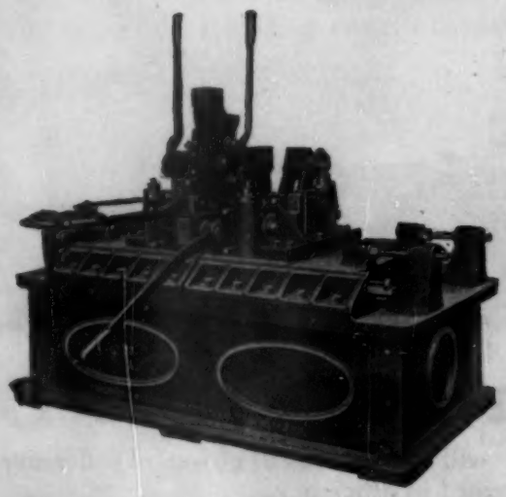

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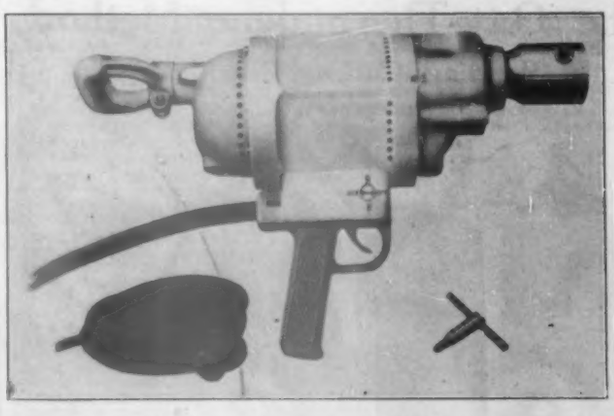

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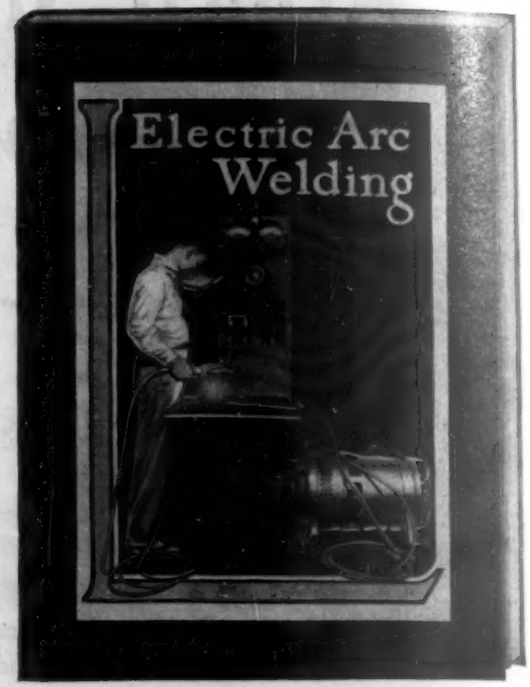

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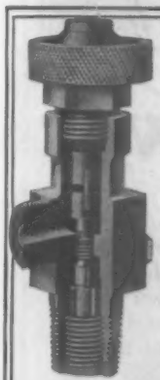

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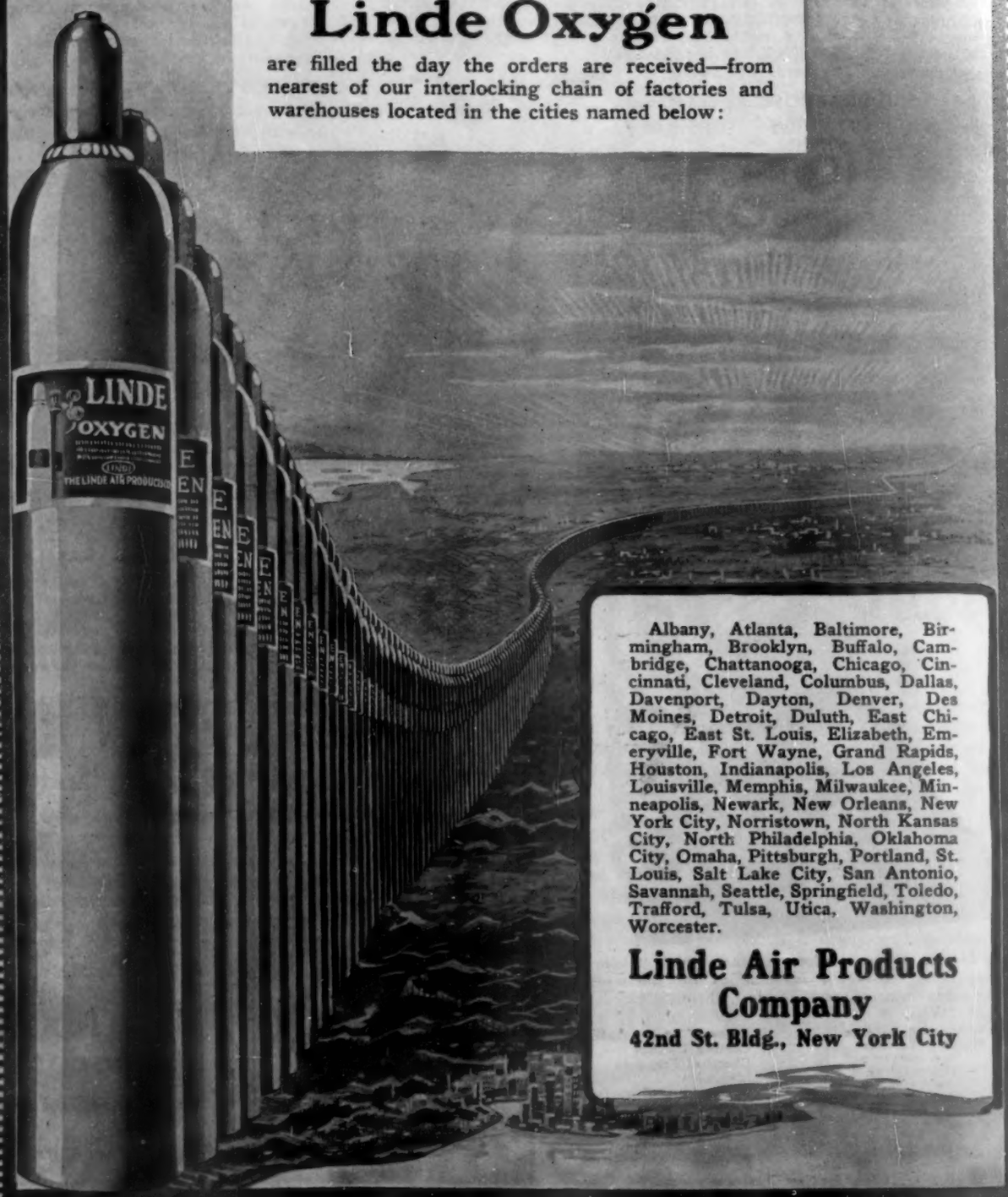

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OXY-ACETYLENE WELDING *of* COPPER, BRASSES *and* BRONZES—II

By M. R. Amedo

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In metallurgical practice, reduction of the oxygen by poling or stirring with a stick of wood has now been replaced or supplemented by reducing agents or deoxidizers in a more convenient form. Among the various elements which have been used for this purpose are phosphorus, zinc, silicon, manganese, iron, sodium, etc.

Phosphorus is probably the best known and the most generally used of all the deoxidizers. It was first used in copper and brass by Parkes of Birmingham in 1849. The addition of phosphorus to copper and its alloys is well known to improve the mechanical properties of the metal, particularly if the quantity is carefully adjusted. If the phosphorus is added in the form of a phosphorus-copper alloy *it readily diffuses throughout the molten bath,* destroying the dissolved oxide. During this purification of the metal the phosphorus is converted into phosphoric oxide which is capable of dissolving a further quantity of oxide. The slag thus formed is very fluid and rises to the surface of the metal, where it *forms a protecting film isolating the molten copper from the atmosphere and the gases of the blowpipe.*

In addition to being a powerful reducing agent, phosphorus considerably reduces the absorption of gases. It follows, therefore, that a weld made with a welding-rod containing phosphorus will tend to be free from oxide. Again, if phosphorus is present during the melting of copper there will be little tendency to oxidize, because this element suppresses the bubbling of effervescence of the molten metal, which is one cause of oxidation, and the phosphoric acid formed on the surface of the metal keeps the molten metal from contact with the atmosphere—the initial cause of oxidation.

It is for these reasons that a welding rod containing a quantity of phosphorus based on a calculation made from the amount of oxide found in a weld normally executed is much too rich in phosphorus.

From a welding point of view phosphorus gives the best result as a deoxidizer. Aluminum, for example gives good results, but possesses the troublesome property in welding of making the molten metal much too fluid. In addition, it is very difficult to manufacture a perfectly homogeneous welding rod containing aluminum.

For electrical purposes the presence of oxide is particularly undesirable, but the use of phosphorus for its removal is not entirely satisfactory, owing to the fact that any slight excess of the metalloid remaining in the copper would seriously affect its conductivity and mechanical properties. For that reason a more satisfactory deoxidizer for copper has been sought, and it is believed to have been found in the substance known as boron sub-oxide.

The Phosphorus-Copper Alloy Welding Rod.

The welding metal used for the oxy-acetylene welding of copper is therefore a phosphorus copper alloy.

A very small quantity of phosphorus is incorporated in the metal, just *sufficient to obtain metal free from oxides.*

In manufacturing this metal it is indispensable to use extremely pure metal, because the simultaneous presence of phosphorus and other impurities of copper produces a bad quality metal.

Phosphorous in the form of phosphor copper, added to electrolytic, is very easily recognized, and may be added and controlled with great precision by simple miscroscopic examination.

The phosphorus is present in the copper in form of a white solution, and its resistance to corrosive agents is much greater than that of the copper itself. The percentage of phosphorus in this phosphorus-copper alloy is extremely low, and numerous tests show that it does not reach one per cent.

At the moment the metal melts under the blowpipe the phosphorus contained in the welding rod automatically deoxidizes the molten metal, and the phosphoric oxide formed rises and floats on the surface of the metal. As stated previously, the percentage of phosphorus is just sufficient to ensure the deoxidization of the metal, the percentage of phosphorus in the welding rod being the average value obtained as the result of a very large number of tests. It is obvious, therefore, that to re-melt a copper weld with the blowpipe oxidizes the metal. Fig. 5 is a micrograph of a phosphorus-copper welding rod which has been submitted to two successive fusions. It will be noticed that there are three distinct zones: the central part, still containing phosphorus (as is shown by the characteristic structure of a phosphor solution); a thin annular part, which is a circle of pure copper; and lastly, the exterior part, consisting of islets of copper (white) surrounded by the eutectic copper—copper oxide.

Welds on copper should never be re-melted without a new addition of welding rod, and, further, in order to improve the appearance of the welds, no superficial melting with the blowpipe should take place unless fresh welding metal is added.

With reference to the manufacture of the phosphorus-copper rod it is important to note that microscopic examination does not show definitely that the whole of the phosphor copper has been perfectly dissolved in the metal.

The presence of undissolved particles of phosphorus always produces fracture of the wire during the wire-drawing operations, and causes the welding metal to lose its malleability.

The presence of free phosphorus is easily recognized under microscopic examination by the presence of white islets surrounded by dark parts of undissolved phosphorus. An electrolytic attack with a solution of hyposulphite of soda darkens for a time the copper and the phosphorus in solution, after which the grains of undissolved phosphorus appear blue.

The uniform manufacture of the phosphorus-copper welding rod can only be obtained after a long series of tests made with a view to establishing a method of manufacture giving uniform results. Unless the manufacture of the metal is controlled, it is not possible to guarantee the perfect homogeneity of the metal.

Welding rods too rich in phosphorus have been placed on the market by certain firms who have failed to carry out a sufficient number of tests to get uniform results, and the presence of an excess of phosphorus in a weld has many disadvantages.

The Welding Rod too Rich in Phosphorus.

A metal too rich in phorphorus lacks fluidity and, in addition, melts at a temperature slightly lower than that of pure copper, thus making it easier to obtain the defect of adhesion.

It is very difficult to get an intimate joining of the added metal with the chamfered edges. It is generally found that a sudden variation in the percentage of phosphorus takes place in passing from the metal melted by the blowpipe to the metal of the plates. A weld of this type submitted to the bending test always separates along the chamfered faces.

A section through a weld made with a welding-rod containing about double the quantity of phosphorus necessary for deoxidization is shown in Fig. 6.

When the percentage of phosphorus *after welding* exceeds 0.2 this would correspond to using a welding-rod much too rich in phosphorus, and such a weld would possess little elongation properties.

The electrical resistance of the metal increases very rapidly with the increase of the percentage of phosphorus. The conductivity of pure copper being taken as 100, that of pure copper containing 0.13 per cent of phosphorus is not more than 70.

In welding electrical connections the use of a welding-rod

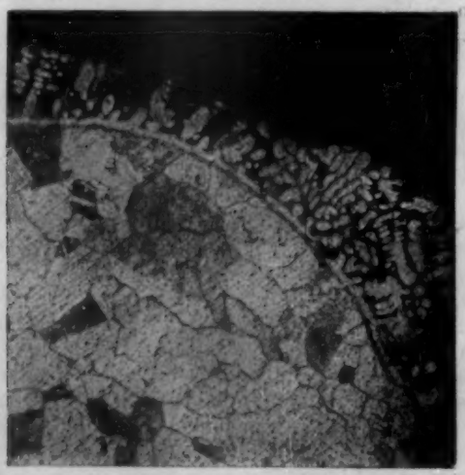

Fig. 6.—Micrograph of a welding metal containing too much phosphorus. (Magnified 50 diameters.)

containing too much phosphorus leads to the resistance of the joint being higher than that of the copper, and as a result, heating the joint takes place, especially in the case of high amperage.

The use of a welding-rod of too large a diameter for welding thin material produces welds containing an excess of phosphorus because the welding-rod is melted in larger masses and is accompanied by less oxidation, which in turn is incapable of utilizing the major portion of the phosphorous which the rod contains.

In conclusion, it is clear that if excess of phosphorus is present the obtaining of a good joint is questionable, and it is indispensable that the manufacture of the copper welding-rod should be constantly supervised and controlled.

The Use of Complex Alloys as Welding Rods.

A very large number of alloys have, in turn, been introduced or proposed for the welding of copper. Their chief characteristic is that their melting point is distinctly lower than the melting point of copper. The elements that have been added to copper to obtain such alloys are very varied; zinc, tin, and even antimony have been used.

The joints obtained with these alloys are inferior, as already mentioned, to those obtained by ordinary brazing. If, for example, we consider the bronze containing 3 per cent of tin, which is frequently used in many workshops under the name of X... metal, or Z... copper, it is obvious, when the difference in the melting point of the added metal and the metal of the plates is taken into account, why it is impossible to obtain a perfect joint.

The rapidity of the work, especially on thin material, is such that it is impossible to obtain diffusion of the tin on both sides of the weld. The solidification of the weld occurs at two places which are very easily recognized. The solidification of the chamfered edges, accelerated by the conductivity, takes place first, followed by the solidification of the joint. The use of a bronze containing 3 per cent of tin therefore gives a "perfect adhesion."

The use of a brass containing 10 per cent of zinc has not the disadvantage of giving, like the bronze just mentioned, a very hard and independent mass in the angle of the chamfer with little elongation properties, but has a tendency to alloy, as in *ordinary brazing when it is used as a brazing metal.* It is very rarely used in this manner in oxy-acetylene workshops.

A brazed joint obtained in this way is very defective, in fact, to join two plates of copper by brazing, necessitates the use of a metal containing a high percentage of zinc. It is a case of forming an intermediate alloy.

A brass of this composition melts at a high temperature and the oxidation at the commencement of brazing is very intense. At this temperature borax is swept by the blowpipe so that the brazing metal is cast between two layers of oxide. It is hardly necessary to say that there is little adherence along the lines of

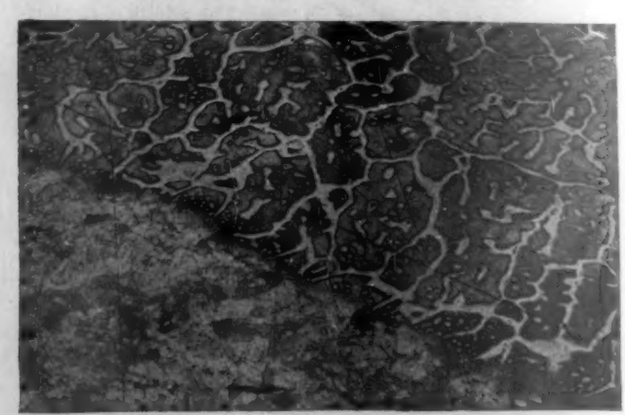

Fig. 5.—A phosphorus copper welding rod submitted to two successive meltings and burnt at the surface. (Magnified 50 diameters.)

welding and what little adherence there is, is extremely weak.

When brass wires are actually used as welding rods for copper, in other words, if the melting of the edges is to accompany that of the welding wire, it is very difficult, owing to the difference between the melting points of the alloy and the copper to be welded, to obtain a perfect joint. It is necessary to maintain the added metal in a molten state for a considerable time before the edges of the welds melt freely. Under these conditions the welding metal, like all brasses, is burnt and its mechanical properties seriously diminished.

This explains why it is absolutely impossible to machine a piece welded in this manner without producing cracks in the weld itself. Satisfactory results cannot be obtained on thick materials when fusible alloys, such as bronze containing 3 per cent of tin, or brasses of high percentage, are used. Tensile tests made on test pieces of copper of ⅜ to ¾-inch in thickness, welded with a bronze containing 3 per cent of tin, only gave an average strength of 16,650 pounds per square inch and an elongation of 5 per cent. The defect of adhesion was common along the chamfered edges.

As to the use of alloys of copper and antimony, it is only necessary to state that the addition of 1 to 2 per cent of antimony to copper produces objectionable effects too well known to require describing in detail here. It is sufficient to state that at the present time such welding rods have been completely abandoned.

EXECUTION OF COPPER WELDS.

It is important in the first place, to note that it is useless to attempt to weld two pieces of copper unless the edges to be welded and their surrounding parts have been raised to a very high temperature near the melting point.

In fact, if the borders of the parts to be welded are not very hot for a certain width, the constant conduction of the heat by the rest of the piece cools the lines of welding whilst the welder is obtaining the molten bath and melting the rod in the chamfer. The result is that the faces of the chamfer solidify whilst the added metal remains molten, and the welder gets the impression that he is executing the work in a normal manner, whereas he is getting the defect of *adhesion*.

It is therefore indispensable to maintain the environs of the parts to be joined, at a very high temperature during the execution of the work.

Those welders who assert that, in order to obtain good copper welds, it is necessary immediately before welding to heat the surrounding parts of the weld much more than the joint itself, are in the right. The numerous adhesions in copper welds are due to neglect of this precaution.

Preheating of Copper.

It may be stated, as a principle, that the welding of copper should always be preceded by heating. If a welder is content to bring the blowpipe on to the lines of welding without previously heating them, the heat of the blowpipe is wasted for some time, and when fusion is produced it is not sufficiently free and thus adhesion is obtained. The welding of thin plates of copper, at which so many welders fail, demonstrates clearly the necessity for constant heating of the parts to be joined.

To a welder, inexperienced on copper work, it may perhaps appear at first sight, that the use of a powerful blowpipe on copper welds would lead to rapid work, as the melting of the edges is produced by a large quantity of heat from the blowpipe. The majority of plates welded on this supposition are simply glued to the added metal.

To successfully weld thin plates of copper, care must be taken not to weld with the white cone too near, as this may be too powerful for melting a very thin layer of metal. On the other hand, the weld should be done with the welding flame held sufficiently far away to give a flame which heats both the edges of the weld, and the joint itself.

The preheating of bars or small pieces of copper may be done with a simple charcoal fire, and therefore the preheating of small articles is always a simple matter.

The problem becomes much more difficult when it is a question of preheating large bodies, such as thick tubes or plates of appreciable size. The most simple method, where the length to be welded is short, is to heat the opposite face with another blowpipe, which should be at least as powerful as the blowpipe used for the actual welding operation.

This method of heating is not practicable when the seam is very long, because in this case the heating by the blowpipe is too irregular. The weld progresses too rapidly in some places and too slowly in others, and the plates have considerable movement, necessitating frequent stoppages for adjustment. The best method in this case is to make a temporary fire below the weld with a suitable ventilator. In this way a uniform temperature is obtained in the immediate neighborhood of the weld, and the work can be carried out rapidly and regularly. To prevent loss of heat by radiation it is well, where possible, to make good use of sheet asbestos, the work is then carried out by the welder with much greater facility.

Whatever method of heating is used—and preheating is indispensable for producing good work—it should not be carried too far because the welder may not be able to control the melting of the metal, and sometimes large holes and the sinking of the metal interrupt the work.

To sum up, the indispensable condition for obtaining good welds on copper is to obtain a *good uniform heating of the edges to be welded and their immediate neighborhood*. In this manner the defect of adhesion is avoided, otherwise it is very common. (To be continued.)

ARC WELDING IN SHOP AND TRACK WORK.

The Harrisburg Railways Company, of Harrisburg, Pa., uses in both shop and track work an arc welder which has been mounted on a low four-wheel truck, so that it may be easily transported from one job to another. In case the transfer is over a considerable distance the outfit is loaded on a motor truck or work car, but for short distances over paved streets, it is fastened on behind an automobile.

The arc welder is enclosed so that the weather and dirt may be excluded when the outfit is not in use. This frame is built up of ⅛x1-inch angle iron, all joints being welded to prevent their loosening under vibration. The frame is covered with ½-inch poplar, which in turn is covered with a roofing canvas. The entire cover, including the frame, is bolted to the platform of the truck so that it may be easily removed. Both sides of the cover are also removable, the back being hinged to provide ventilation and the front being entirely removable to afford easy access to the switchboard, etc. When the outfit is in operation the front cover is placed on top of the outfit to form a shelf for tools. The outfit is used in the shops for miscellaneous repairs, some of which are of unusual interest.

A GE-80 motor base which had been cut out by the pinion coming loose was simply and effectively repaired by the arc welder. With a cutting torch a discarded street car gong was cut down to the proper size and split in the middle. The two halves were then welded onto the case over the worn portion, rendering the case practically as good as new and at a cost of about 45 cents.—*Electric Traction.*

WELDING PROFITS.

It is not stating it too strong to say that every blacksmith should have an oxy-acetylene welding outfit. Some may say, "But I have little call for welding." And you never will as long as you do not have the outfit. Nor will you have much call to do welding jobs, even though you have the outfit if you do not make that fact plain to your customers. Tell them that the whole idea of welding has been revolutionized since the introduction of this process. It enables one to do work that could not be done before, and better work than it was possible to do before.

This is the metal and the machine age. The machine may now be found on the farm, in the kitchen and the sitting room, and in the office and factory.

Do not forget that the old-fashioned welding meant the binding together of two pieces of metal by means of something that had adhesive qualities. Oxy-acetylene welding is fusing together of two pieces of metal into a solid piece of the same character and structure.

There are several kinds of welding and cutting outfits on the market just as there are several kinds of pianos and plows, but in any case they are now sold at prices that merely give the manufacturer a fair profit on their production. No matter whom you may buy of, detailed instructions for setting up and adjusting, as well as for doing the work, will cheerfully be given to those asking it.—*Blacksmith & Wheelwright.*

KLEIN NEW SALES MANAGER.

The International Oxygen Co. announces the appointment of R. M. Klein as sales manager, with headquarters at the company's main office, 115 Broadway, New York. Mr. Klein brings to his new position a thorough technical training and a comprehensive experience as an engineer in the United States Government employ, as salesman and sales manager for the Diehl Manufacturing Co., and as manufacturers' representative handling a number of mechanical lines. He entered upon his new association on July 1st.

WELDS—*The* WEAKNESS *and* MERITS *of* THEIR STRUCTURE†

By P. A. E. Armstrong*

SYNOPSIS—The author believes that welding is unquestionably the future means of joining the sheets of pressure vessels. The structure of the metal of the plates and that in the weld are entirely different ordinarily, though alike in chemical composition. The high temperature to which the metal being welded is subject is usually of such long duration as to cause serious growth of the crystals. Burned structure is the result of incipient fusion and is caused by the crystal beginning to melt at the crystal boundaries. The plates to be welded should be "tacked" the whole length of the joint, and the weld completed by filling the V for its entire length with thin layers of the filling metal, one layer being completed before beginning the next. This avoids internal stresses in the weld from shrinkage of the cast metal and prevents serious growth of the crystals in the plates.

Welding is of immediate and considerable importance to the power-station engineer and to the power-plant manager. Although the engineer is not actually interested in the manufacture of articles that are to be welded, he has to use pressure vessels, boilers, etc., that are wholly or partly welded. Under these circumstances his interest is perhaps a little more pertinent than that of the manufacturer, as the engineer has to be both responsible for these various tanks and live beside them.

Welding Must Receive Deeper Study

Many questions are raised as to the safety of welding, as to the best system and whether welding should be permitted for high-pressure work. It would be as well to deeply consider the essential points necessary for safe welding and try to find the reason why some welds are not good and others are satisfactory. I am convinced that the subject of welding is not receiving the careful investigation that it deserves, as welding is unquestionably the future means of joining one plate to another.

The art of riveting has received considerable attention, and the science has been reduced to a basis where the engineer can make a definite calculation as to the strength and service of a riveted joint. Why should not he be able to reduce welding to such a state that he can make calculations with a fair assurance that they are accurate?

At the present time there are two widely known systems employed for welding—oxyacetylene (that is, gas welding) and electric welding (that is, welding by means of an electric arc and metal electrode). Both these systems have their respective champions, but there are a number of undesirable features present with either, which could be eliminated if the necessary metallurgical knowledge were applied.

Two steel plates that have been welded are joined by a metal of like, or nearly like, chemical composition, but the structure of these metals is entirely different. The plate was originally cast structure, but has been refined by the operations of mechanical work and heat-treatment. The structure of the added metal, due to welding, is cast metal and cannot be subjected, generally speaking, to mechanical work, although it can be subjected to heat-treatment. Weakness of a welded joint is unquestionably due to three things: (1) Faulty welding; (2) the weakness of the structure of the added metal; (3) thermal disturbance in the vicinity of the weld on the plates being welded.

To remove the cause of faulty welding—by that I mean adjacent areas which, although fused, are not fused together so that there are no interposing slag lines or oxide lines—it is necessary that the added metal and the original metal should both be brought to a molten state so that the new melt will flow on the original metal, which is made molten in such a way that the oxide and other impurities float to the surface of the molten metal and do not remain buried in the molten mass and weaken it. This can be readily accomplished by having sufficient heat to cause a very liquid melt and maintaining this liquid melt for sufficient time to enable the inclosed impurities to rise to the surface.

The restrictions placed upon this condition are those of increased size of the crystal structure of the plate to be welded, because of the period of high temperature to which it is submitted; therefore it is necessary to use very intense but extremely local heat. In preventing grain growth we are assisted by the original plate, owing to the lag present in the crystal changes, time playing an important part. It is possible to heat a piece of low-carbon steel to a temperature up to fusion without increasing the size of the crystals, but to do this it is necessary that the heat be applied only for a very short period.

Fig. 1, which is a photomicrograph, shows a piece of steel about 0.45 per cent. carbon, which has had added to it mild steel deposited by means of a metal electrode and the electric arc. This photomicrograph is of great interest, as it shows the little understood and less appreciated fact that the crystal structure of steel is changed by time multiplied by heat and not heat multiplied by time. This is of no moment where ordinary heating is concerned, but where welding is to be considered it is indeed important.

The rapid growth of the grain size of mild steel is very marked if a piece of mild steel plate is heated to, say, 1,000 deg. C. (1832 deg. F.) for but a short time. The crystal structure will be found to have grown to such an extent that the grain size is readily discernible to the eye without magnification, and if the steel is still further heated, the crystals take on a coarse angular structure common to overheated steels.

"Burned Metal" Merely Incipient Fusion

The burnt structure, about which so many statements have been made, generally to the effect that in welding the structure of the steel adjacent to the weld must necessarily be burnt and for that reason useless, does not hold true in the instance as shown in Fig. 1. There is no burnt structure here. Burnt structure means incipient fusion and is caused by the crystal beginning to melt in the portions of the crystal which froze last, when it was originally cast. This can occur either at the crystal boundaries or in the heart of the crystal, but is generally at the crystal boundaries. All commercially made steel contains occluded gases—oxygen, hydrogen, nitrogen, etc. Directly incipient fusion starts, the occluded gases, particularly the oxygen, combine with the metal that has started to melt, forming an iron oxide which

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is readily discernible under the microscope. Such metal is weak along its crystal boundaries, first, because of this iron oxide and, second, because of the "pine tree" structure caused by the solidifying of the molten portions of the crystals which have started to melt at the time of incipient fusion. Such a structure is useless by reason of its great crystal boundary weakness, due not so much to reduced tensile strength as to its poor resistance to shock or alternating stress. All burnt metal is intercrystallinely weak, whereas normal mild steel is strongest to shock load at its crystal boundaries. From this it is readily understood that there are sound metallurgical reasons why the fusing of the metal to be welded should not be done with an agent that is not extremely local and intensely hot.

Gas welding gives good results for thin plate work, because the heat is sufficiently local and intense to make a satisfactory weld in such time that the original plate does not suffer materially from incipient fusion; but where a thicker plate, for instance, over ⅛ in., is concerned, then oxyacetylene sets up distinct thermal disturbance in the vicinity of the weld, due to the prolonged time the flame has to be applied to the part to be welded to raise it to the fusing temperature.

The electric arc with metal wire as an electrode is not much better because of the method of application, although the metal electrode used with the electric arc is an extremely local method of heating.

The work to be welded is generally V'd and the entire V is filled up and sometimes reinforced at one application. That is to say, the weld is started and the V at the cross-section is filled up higher than the level of the surrounding metal as the electrode is brought along the work. In this respect it is practically the same as the oxyacetylene. The electric arc, although being very local and extremely hot, is kept in one position for such a long time that there is distinct crystal growth in the vicinity of the weld and incipient fusion takes place. This system, therefore, does not have any advantages over the oxyacetylene and in fact is not as good, because the cooling of the metal is quicker and the cast metal is in an extremely chilled state, whereas with oxyacetylene, although the thermal disturbance near the weld is much greater, the added metal is not in such a chilled state and in many instances is found to be stronger and more ductile, this being largely due to the added metal chilling much more slowly.

Fig. 3 shows two plates V'd out and welded in the usual way by the oxyacetylene method. Fig. 4 shows these two plates welded by the electric arc usual method. Fig. 5 shows two plates welded and the V filled up by a number of layers, each running the entire length of the welded plates.

Figs. 3 and 4 are subjected to enormous strains due to the contraction of the cast metal; steel shrinks about 3-16 in. to the foot. A plate ½ in. thick with a V of 90 deg. will have an area to be filled in at the top of the plate of about ¾ in. wide, and when the sides have been melted, probably ⅞ to 1 in. The molten metal will then have to shrink at the top about 1-64 in. The major part of this shrinkage takes place when the metal is at its weakest stage; that is, at the time of the solidification and in the plastic stage. In the event of the plate not lifting or pulling sufficiently to take care of this shrinkage, the cast metal of the weld will be found to crack for some distance in the weld. These cracks are more noticeable in electric welds than in gas welds, because in the latter the metal is put down in a number of globules which are spread over by the action of the flame in layer form and the shrinkage is partly taken care of by these layers and partly by the slower freezing of the added metal. The metal electrode and the electric arc deposit larger quantities of metal, the operation being much quicker, but the shrinkage is not so well taken care of and there is a too rapid chilling.

The benefits derived from gas welding are, however, offset by the added thermal disturbance in the surrounding plate because of the time necessary to take care of this slower application.

Fig. 5 shows the metal put down in a number of longitudinal seams. It is not possible to so weld two pieces of metal with the oxyacetylene torch in its present state of development and show any sort of economy in time and cost. The electric arc alone is applicable to this method, and even then the electrode employed must be of such construction as will lend itself to this type of welding. This is being done, and

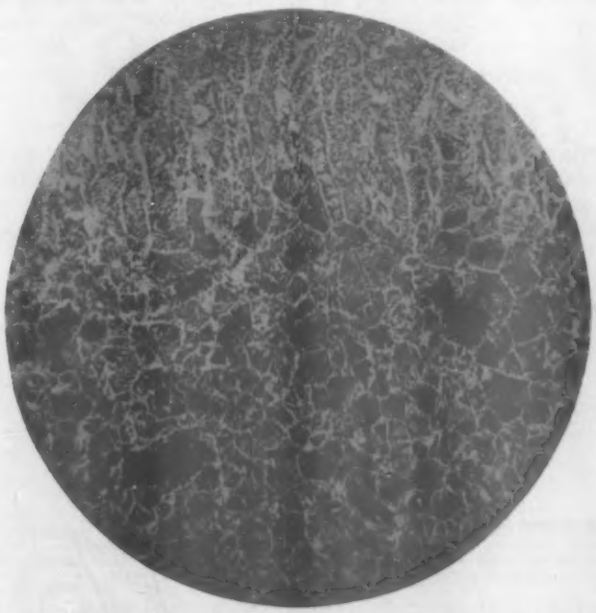


Fig. 1. Photomicrograph, Showing One Layer of 0.20 Per Cent Carbon (Mild) Steel Upon 0.45 Per Cent Carbon Steel.

There is no sign of crystal growth even immediately adjacent to the added metal which has a "pine tree" structure. The black is pearlite, white is ferrite. The added metal is at the top.

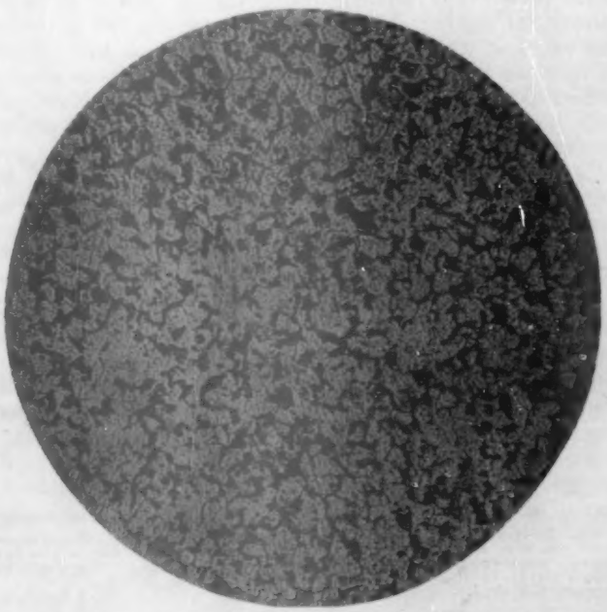


Fig. 2. Showing Refining Effect of Heat by Adding the Metal One Layer at a Time.

This fine structure represents the best structure obtainable in annealed low carbon cast steel. Note the uniformity of structure and absence of segregation.

the welds thus produced have been found to be far superior to welds made according to Figs. 3 and 4. The thermal disturbance in Fig. 5 is extremely small.

Fig. 1 is a photograph of the structure of a piece of steel which has been welded one layer thick by this method. As will be seen, there is no thermal disturbance in the vicinity of the weld, but the added metal shows distinct rapid cooling and must be refined. Each successive layer that is put down has the effect of heat-treating the under layer, thereby refining the grain and giving a very small, dense structure, as seen in Fig. 2, which was taken in the heart of such a weld.

It will naturally be asked, If this method of welding does not set up crystalline growth in the original steel, owing to the heat being of such a short period, then how can the heat caused by successive layers have any effect upon the structure of the cast metal which is the weld? The answer is this: (1) The heat necessary to cause crystal growth must be much greater than the heat necessary to refine the grain; (2) the cross-section of the layers is extremely small compared with the cross-section of the original metal. Therefore the heat conveyance or radiation of the narrow layers is not sufficiently quick to take away the heat before the crystals have had time to change. The heat set up in laying down a fresh layer of metal is sufficient to refine the under layer, but it is nevertheless necessary that these layers be narrow and as thin as possible. The strongest weld by this system is the one where the greatest number of narrow thin layers have been made.

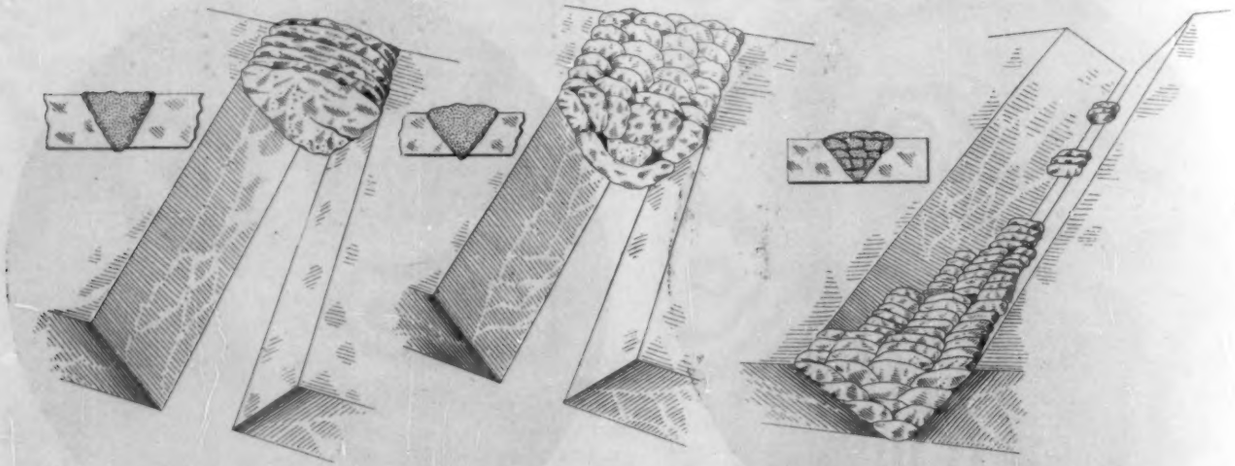
The time employed in making such a weld is of necessity slightly greater than where the system shown in Figs. 3 and 4 is employed, but the additional time does not amount to very much and the increased cost is not sufficient to warrant the rejection of the system on this ground.

The method of welding Fig. 5 also makes it possible to set the plates to be welded so that they are gapped in parallel and not set 1 in. or so apart at one end and touching at the other, as is the case with plates some feet long which are welded as in Figs. 3 and 4.

If two plates of ½-in. steel are to be welded, each plate being 2 ft. long and V'd 90 deg. and welded by oxyacetylene under the normal conditions as per Fig. 3, then one end of the plate will be made to touch and the other end will be set apart from 1 to 2 in., according to the skill of the operator, and it will be found that when the plates have been welded their entire length, the end at which the plates have been set apart is so closed that the edges are touching. This has set up an enormous strain throughout the weld, which undoubtedly materially affects the strength of the plate, particularly as far as resistance to shock is concerned.

If these two plates are welded by means of the metal electrode and electric arc, as per Fig. 4, the plates will not be set so far apart, but nevertheless there will be an enormous strain set up in the weld, because of the constant closing in of the plate. In fact, many such welded plates, when tapped with a hammer so that a rhythmic vibration is set up, will be found to crack and spring apart, perhaps for half their entire length.

Two plates of the same thickness and length welded as per Fig. 5 are not set apart more at one end than at the other, but are set consistently about ⅛ in. apart top and bottom. The plates will then be welded in spots (tacked) about every 6 in. along the length of the plate and afterward welded the entire length one thin layer thick. The plate is now a solid mass—joined the whole length. The metal is not subjected to any strains, the thin layer having been quite capable of taking care of its own shrinkage, which was extremely small. As each successive layer is put down, the shrinkage is taken care of in the layer. The layer is of much less cross-section than the plate and therefore does not have any tendency to lift the plate and close in the top of the V.



Figs. 3 to 5. Methods of Laying Down Added Metal When Welding.

Fig. 3—Oxyacetylene welding, filling complete in one operation. The wide gap is drawn together by the contraction of the added metal in the weld, tending to break through the weld.

Fig. 4—Electric arc metal electrode welding, filling in one operation by carrying electrode from one side to the other. Gap is closed as in Fig. 3.

Fig. 5—Electric arc metal electrode welding, filling by putting down one thin layer upon another, thus heating. Treating each layer when laying down the next. The bottom of the V is tacked.

Having shown the mechanical method of overcoming abnormal shrinkage in the cast metal and a way of refining the cast metal by successive layers, it is logical to consider the methods and conditions under which the metal is made molten:

Protection Against Oxides and Gases.

All metal that is melted must be protected from the effects of the atmosphere, to prevent oxides forming and the metal becoming saturated with oxygen and nitrogen. The manufacturer of openhearth steel is troubled with oxides and nitrides which permeate the metal due to gas impregnation arising from the partly consumed air in the heating gases. The electric steel furnace is not so troubled, because the melt takes place in a neutral atmosphere, the arc consisting of vaporized lime—in other words, a vaporized slag arc. If it were not for this type of electric arc, and should the arc consist of incandescent atmospheric gases, then the melt in the electric steel furnace would be distinctly inferior to the openhearth melt.

For thin plate work oxyacetylene is a very desirable method of welding from a quantity production point of view

provided the flame can be kept neutral. In practice this is not possible, because of the changes in the pressure of the oxygen and acetylene gases. This defect can be remedied, however, if an automatic valve is designed so as to control the mixing of the gases and maintain the flame always in the neutral condition. I do not know of any such arrangement, but there is no reason why this should not be done, and it is one of the desirable developments that should be undertaken by the manufacturers of oxyacetylene welding apparatus.

Welding by oxyacetylene is generally done by means of an oxidizing flame. This cannot be traced on the surface of the steel, but the metal is full of occluded oxygen and therefore extremely weak in its resistance to shock, although in some instances stronger than the more oxygen-free metal as far as tensile strength is concerned. If the flame is carbonizing, which can easily happen, the weld is still troubled with occluded oxygen, because of the affinity of oxygen for carbon. The carbon deposit is partly consumed by the oxygen of the atmosphere, and the excess oxygen impregnates the added metal to the detriment of the weld. Therefore, the weld is very porous, being full of occluded gas and iron carbides. If this is carried to excess, the deposited metal is actually white iron, 2 per cent. carbon, in which case the weld cannot be filed and is in an extremely brittle state.

The electric arc, where the metal electrode is used, is entirely an oxidizing one, the arc being composed of incandescent atmospheric gases. The iron is so quickly rusted away by the highly oxidizing nature of the arc that red rust abounds everywhere in the vicinity of the arc and can be found not only in large quantities on the work, but in the nostrils of the operator. As previously pointed out, it is not possible to make good steel while it is being subjected to the oxidizing influence of the atmosphere. Therefore metal deposited by means of the electric arc, wherein no provisions have been made to eliminate the oxygen or degasify the melt, must necessarily give a very weak structure and contain iron oxide, particularly between the added metal and original plate.

Direct Current Sets by Electrolysis.

Another difficulty presented in the electric-arc welding arises from electrolysis. It is the practice almost without exception to weld with direct current, using the work to be welded as the positive pole and the electrode to be melted as the negative pole. This is done so as to have the hottest part of the arc where the area of metal is greatest. In theory, this is good, but direct current sets up electrolysis and the impurities are collected on the positive side of the line, likewise the oxides. Under these circumstancs the weld is literally permeated with impurities by electrolysis. If the poles were reversed, then the metal deposited would be freer from the bad effects of electrolysis. Unfortunately it would be very difficult to make a good weld with the bare wire electrode having the work as the negative pole. The metal would be deposited all right, but there would be no fusion or only partial fusion between the deposited metal and the original steel. The heat developed would have the effect of melting away the electrode much quicker than the original plates, owing to the larger cross-section and the more rapid heat radiation.

May Coat Electrode with Refractory Tube.

The only means of overcoming this difficulty is to localize the effect of the arc in a much more marked manner than can be accomplished with the ordinary metal electrode and electric arc. This can be done by coating the electrode with refractory material, thereby directing the arc inside a tube, as it were, onto the work and getting the full benefit of the heat arising from the electric arc. It will be found that there is very little difference in the heat of either pole. Such refractory materials would melt away quickly enough to maintain a uniform distance between the end of the metal electrode and the work. Furthermore, the atmosphere of the arc would then be that of its nearest gases and, like the electric furnace, would be the atmosphere arising from the gasified refractories. The atmosphere of such an arc would be but slightly oxidizing, if not quite neutral.

With this type of electrode it is possible to use alternating current, which is quite free from electrolysis, thereby enabling the steel to be deposited free from the harmful effects of electrolysis, or if direct current were used, then the work would always be the negative pole.

In testing welds it is important that they be tested in such a manner as to anticipate failure through fatigue. The cast structure, which is the welded material, is fairly strong as far as tensile strength is concerned. Its elastic limit is quite high and very near to its tensile strength; the elongation is very low, likewise the reduction of area. To submit welded pieces to the usual tests of tension, elastic limit, elongation and reduction of area does not throw as much light upon the strength of the weld as is desirable. If a piece of 0.35 per cent. carbon steel is welded, the tensile strength of the welded metal is perhaps 10,000 lb. under the tensile strength of the original plate and the elastic limit of the welded metal may be only 200 lb. under its tensile strength. In pulling the sample the original plate will start to "neck" away from the weld generally, if an oxyacetylene weld, about ⅜ in. to ½ in. away from the weld; that is, in the area that has been annealed, or overheated, owing to the thermal disturbance. This necking sets up reduced cross-section; the weld not having suffered from reduced area, is now of greater cross-section than the original steel. The break does not occur in the weld, but in the original steel.

It is erroneously thought that the weld is as strong as the original plate, but this is obviously not so. In the case of an electric weld by means of the ordinary bare wire, the elastic limit and tensile strength of the added metal of the weld are about the same, and the tensile strength is probably two-thirds the tensile strength of a 0.35 per cent carbon plate. Necking will take place away from the weld, likewise the break, and the weld is erroneously thought to be as strong as the original steel.

To test a welded plate, it is necessary to first test an unwelded piece of the same steel and then prepare the sample so that the welded area is necked, the necked portion not being taken back as far as the edges of the weld. The sample then being pulled, the true tensile strength, elastic limit, elongation and the reduction of area of the welded metal will be discovered.

Advises Hydrostatic Hammer Blow Test.

In all cast metal, if the elastic limit is high, the metal is dangerous, because it will be found to have very little so-called anti-fatigue value. It is important to test this value where pressure tanks are concerned or where vibrations are likely to occur. Impure cast metal—that is, metal high in impurities, phosphorus and sulphur—or metals rich in combined gases are all liable to sudden rupture when submitted to shock load. Therefore, it is important when testing welds, that a shock or vibration load test be submitted. I would advise that a sample piece that has been welded should be submitted to an alternating-stress test machine, or even tested by a rotary-stress test machine, of the Arnold type. The finished tank, on which tensile-strength tests cannot be made, should be submitted to water pressure, there being no danger in such testing, and the welded joint tested by a number of blows by the hammer or by a specially designed machine that will deliver a given blow at a given speed, travelling at a predetermined rate. A weld thus tested, if faulty, will immediately break, and a good weld will not be damaged by

such treatment. There is a very wide margin between good and bad cast steels which have been broken during shock and vibratory tests. Steels that are faulty will break quickly, whereas steels that are capable of resisting shock load will stand quite a lot of shock-testing before they break.

In alternating-stress testing, the crystals of the metal begin to show signs of slip along their cleavage planes, and unless these cleavage planes actually show signs of fissures, the metal has not been seriously damaged. In fact, a polished specimen of very mild steel can be tested to, say, 30,000 reversals at 15-ton load and the amount of deformation set up along the cleavage planes will not have reached the danger limit, and the signs of slip along these cleavage planes can be repolished out and cannot then be traced under the microscope.

When testing for resistance to alternating stress or shock, weak metal will quickly break because of crystalline weakness, whereas the normal break of good steel is directly across the cleavage planes and not around the crystal boundaries, as such boundaries are considerably stronger mechanically than the body of the crystal.

Testing a welded pressure tank and boiler by rhythmic hammer blows is not impact-shock testing, but alternate stressing, due to vibration, and the hammer blow is never sufficient to set up deformation or cold working of a serious nature. There cannot thus be any objection on the score of premature damage to an otherwise sound tank by this method of testing.

THE LARGEST WELDING JOB.

By Carl E. Johnson.

The accompanying photographs show clearly what can be done with the oxy-acetylene process. We have had many heavy jobs, but the hydraulic punch frame illustrated is to the writer's best knowledge the largest on record.

The Frost Manufacturing Co., Galesburg, Ill., found themselves greatly handicapped by the sudden breaking of this punch frame, which had been in service in their plant about 17 years, and which was guaranteed to punch a 6-inch hole in 1-inch steel plate.

Some of the largest welding concerns in the country refused to undertake this welding job, but due to delay in

The big casting. White lines show break.

obtaining a new frame, it was imperative to have the job done. The Frost Manufacturing Co. was finally referred to our company, the American Boiler Welding Co., Chicago, as being specialists in the line of heavy work, and after looking at the job, we not only agreed to weld the casting, but agreed to guarantee the casting for one year.

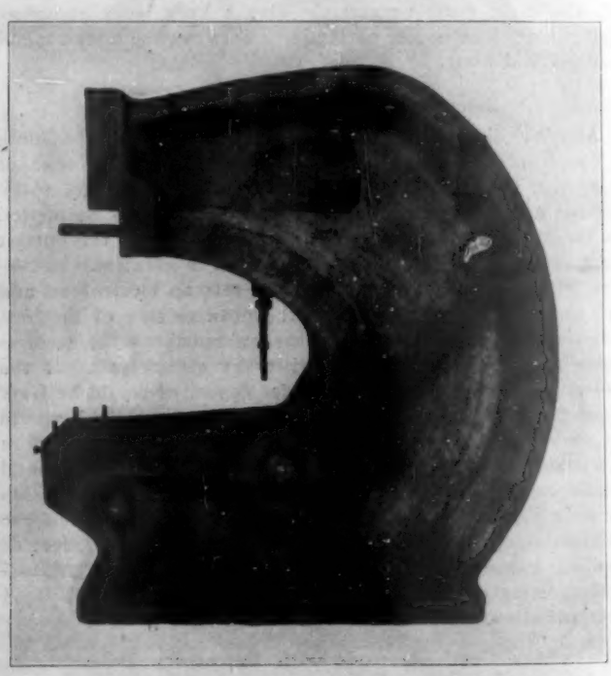
We acknowledge that we had no easy time doing the work, and that it took all our facilities to handle it, but it was completed and is now in daily service.

The break at rear of the throat of this punch was 10 inches thick and 24 inches wide. The web is 4 inches thick and crack extended upward from throat and down to

Actual welding was done by Mr. Johnson, assisted by Sam Larson and Nick Robel.

base through somewhat, heavier metal 66 inches also across base of casting measuring 34 inches wide and 4 inches thick; *weight* approximately 17,000 pounds.

No welder needs to be told of the difficulty of successfully welding a job of this magnitude. We used 6,800 pounds of charcoal for preheating, and 1,480 pounds of



The finished weld—Note how line of weld is built up.

cast iron filler rods. Of course, this includes metal for reinforcing which was done thoroughly as will be noted from illustration. We are also particularly proud of the fact that throughout the entire operation not one of our welding tips were burned, nor was any injury done to the torches, regulators, etc.

OXY-ACETYLENE ADVANCED OPERATIONS

By B. Kofferschmidt

The only time when oxy-acetylene welding is really appreciated and found indispensable, is when a broken expensive casting, that may cause a tie up of a plant, is welded in a few hours and replaced in service.

There is no doubt that the smaller welding operations have there importance, but it is the big jobs that are holding up the plant.

For some reason a few of our welders are quite successful in mastering these big jobs, and the author gives below a few operations he performed that were pronounced by others as impossible or unweldable.

Fig. 2.—Main bearing broken on a shear press before welding.

The author does not intend to criticise these men, nor does he care to appear as the only one that knows, but he intends to co-operate with his comrades, to give them advice if possible and he believes that no welder should give up a job as unweldable, before consulting some one. A great many welders believe that when asking advice that they are lowering their prestige. This welder is just as much in the wrong as the welder who deliberately refuses advice. The editor of this paper will cheerfully give free advice and co-operate with the men in the field. Without co-operation there could be no specialization of the welding trade. The man who refuses to ask advice and consequently pronounces a difficult job as unweldable, is the man who deliberately puts his foot in the machinery of his own best interest. He stops his machinery and crushes his foot rather than ask advice that is given to any man confidentially and gratis.

Accumulator Cylinder Welded.

An interesting subject recently welded was a cracked cast steel accumulator from one of the largest presses of The Haskell Barker Car Company Plant, Michigan City, Ind.

This company maintains a welding force for the welding of steel cars and other normal operations. This cylinder was intrusted to them for welding. However, they were unsuccessful in their efforts, as the crack opened up again and also extended a few inches longer. The management then decided on a prominent welding firm. However, they were not more successful than the first party and the crack still extended liberally, and they left the job as unweldable. This being an expensive casting the management tried a

Fig. 3.—Main bearing broken on a shear press after welding.

Chicago welding establishment. When the Chicago people arrived at the ground, they pronounced the job unweldable, and mentioned other examples where similar jobs could not be welded.

A few days later the author happened to visit this plant and he was asked for advice, with the result that he promised to weld the cylinder.

Method of Welding.

The writer first investigated the cause of the defect and found that on account of the vibration the metal all around the cylinder, in the neighborhood of the crack, was crystallized. The method of detecting crystallized steel is to cut a little in the metal with a hammer and a chisel, and then break the piece off. If the grain on the fractured piece of steel is found coarse (similar to gray iron), then it is crystallized. If the metal has a fine grain then it is good for welding. In this case the grain of the metal was found coarse and it was necessary to anneal that portion of the cylinder previous to welding. Then two 5/8-inch holes were drilled on each end of crack and chipped to a 45° angle from one hole to another. After the 20-ft. cylinder was set on proper and level foundation with many supports, a brick furnace was built around the cylinder, the same length as the crack, and preheated with charcoal and coke for about five hours. Then the writer, with another shop welder, had no

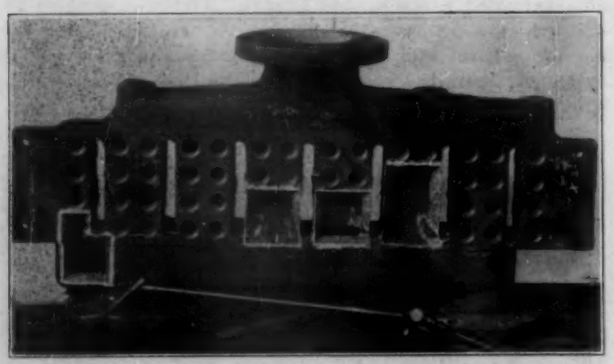


Fig. 4.—Superheater Header broken in four places.

trouble in welding the crack in about seven hours. After the cylinder was cool, the weld was given a double test with good results. This cylinder has been in constant service since June 10th.

Fig. 2 shows a large shear press from the Jackson Rim Company, Jackson, Mich. The press was broken at the main bearing and a local welder, as well as their own welding force, could not undertake this operation. Fig. 2 shows only the upper portion of the press, set ready for preheating. The broken piece is shown below on the asbestos, already chipped and ready for clamping.

Method of Welding.

As it required two vertical welds on each side of the broken bearing, carbons were cut out to suit the shape of the casting and grooved out so as to reinforce the casting at the welding line. Then a brick oven was built around the fracture to preheat the heavy metal. When it became cherry red the bottom carbon block was placed and the space this made between carbon and casting including the bevel was welded to the height of the carbon block. Then another carbon block was placed and so on until the whole weld was completed. Great care was taken to have the broken bearing lined up exactly with the other two bearings, otherwise the best weld would be useless.

Fig. 3 shows the same press after welding and ready for service.

Fig. 4 shows a superheater header, cracked in four different cylinders. Although we have successfully welded some with only one cracked cylinder, yet if more then one cylinder is cracked they are slated for the scrape pile. There is no reason why four cylinders could not be welded as well as only one.

Method of Welding.

Four pieces were cut out on the face of the casting, as shown in Fig. 4, and the edges bevelled to a 45° angle. Then four new pieces were made and the edges bevelled to fit into the four holes. Then the internal cylinder crackes were also chipped to a 45° bevel and carbon blocks ½-inch thick were cut to fit the internal cylinder cracks, for the purpose of welding them in a vertical position. After these operations the casting was set in a horizontal position, face up, and a furnace built all around the header, leaving a six-inch fuel displacement for charcoal and coke. In building the furnace care was taken to separate the bottom row of bricks about one inch apart for draft purposes. After the fuel was kindled with the aid of the welding blowpipe, and the casting preheated for about five hours, the header became cherry red and ready for welding. Two operators

Fig. 5.—Compound Locomotive Cylinder broken before welding.

started to weld the internal cylinder cracks with the aid of the prepared carbon blocks, by placing them one at a time from bottom up. After these welds were finished, the top prepared pieces were placed in their respective holes, and welded one at a time. When all the welding was finished, the bottom row of holes and any other crevices or openings of the furnace, were closed with the fire clay and it required 12 hours for cooling before the casting could be machined.

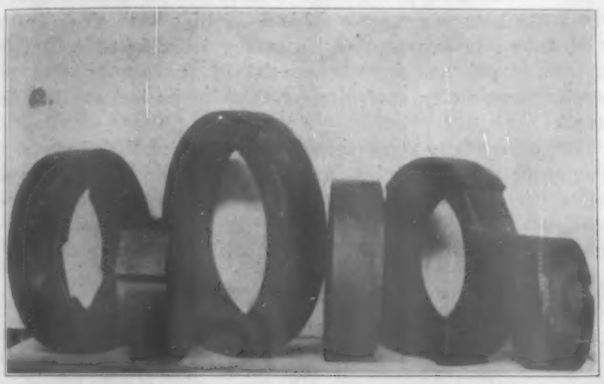
Fig. 5 shows a low pressure locomotive cylinder, that was slated for the scrape pile on account of the large hole, and because one of the broken pieces was missing. However, the writer explained that the larger hole would not prevent him from welding the cylinder, as it only means a few hours more welding. As for the missing piece, he cut out a cylinder piece from an old scrapped cylinder of the same type. The bottom fracture was bevelled to a 45° angle so it could not be welded from the inside of the cylinder. The upper fractures were bevelled so the welds could be made from the outside, from the bottom up. For this purpose one inch thick carbon blocks were shaped, grooved, and numerated from bottom up and prepared previous to preheating. The making of the furnace and preheating time can be found in July, 1917, issue of this paper, page 21. After lower portion of the cylinder was red hot, one operator started to weld the bottom fracture, beginning from the flange. Another operator started to place No. 1 carbon on

the outside bevel and so on until he reached the upper end of the flange. When all welding was finished the holes and openings were closed with fire clay and left to cool 24 hours, and the job was finished.

THE STRUCTURE OF WELDS AS APPLIED TO PRESSURE VESSELS.

There are three divisions of opinions in the present attitude toward welding for pressure vessels, such as boilers, water tanks, ammonia coolers and receivers. First is the manufacturer, who, for cost and production reasons, advocates and applies welding wherever he can and who looks with a sour eye upon all who question the reliability of his welds. Secondly, there are the officers charged with public safety, the insurance companies and others who are just as determined not to allow the use of welds in tension. Happily, the third division comprises those engineers and metallurgists who appreciate all that is desirable in welding, but realize that because of the uncertainty of the strength of the weld the hazards, especially in the case of high-pressure boilers, are too great at this stage of the development of the art to permit the unrestricted application of anybody's weld anywhere.

Up to the present there has been too little of the scientific in relation to welding. The shortest path to success and



Interesting cutting done on Oxygraph Sanderson Steel .110 pt. carbon. Done at Chicago Shops.

development of reliable and uniform welds is the study of the microstructure of welded parts by metallurgists skilled in the miscrostructure of metals, particularly iron and steel, and by physicists.

In welding one is dealing with metal crystals, microscopic bodies made up of molecules, which consist of atoms that in turn, according to modern science, are composed of electrons. When a weld or the metal near the weld breaks, it breaks either at the crystal boundaries or through the crystals. In welding it is the manner of application, the time and the intensity of heat and temperature chiefly that determine whether the crystals of the weld and of the metal near the weld are going to hold together under the stresses imposed by the service to which the joint is to be subjected.

How the crystals are affected is admirably brought out by P. A. E. Armstrong in an article in this issue, probably the most scientific and valuable article yet published on the miscrostructure of welds. The practical welder and the engineer cannot but be impressed by the author's contention that the joint before welding should be "tacked" for its entire length and the V filled in by the cast metal in layers, each layer running the full length of the joint and being laid down for the entire length of the joint before the second layer is started. Mr. Armstrong claims that when the V is filled by the welder as he proceeds from one end of the joint to the other, as is done ordinarily, the metal of the weld and the metal near the weld are kept so hot for so long a time that crystal growth of a serious nature is the result, with consequent serious internal stresses. The purpose of filling the V with thin layers of the cast metal is to heat-treat the metal of the weld and of the joint as the weld progresses toward completion. This, of course, amounts to saying that if the welding is properly done there is no need of preheating the plate unless the plate or the material to be welded is much thicker than ordinary tank or boiler plate.

The author says that in testing welds the test should be made in such manner as to anticipate failure through fatigue. The cast structure, which is the welded material, is fairly high in tensile strength; its elastic limit is high and very near to the tensile strength; the elongation is very low, so also is the reduction of area. He contends, therefore, that to submit welded pieces to the usual tests of tension, elastic limit, elongation and reduction of area, does not throw so much light upon the strength of the weld as is desirable. Instead, the shock of vibration test is recommended. This is in accordance with modern opinions. For

WELDING AND CUTTING DEPARTMENT

Indiana, Pa., ... 191

CHARGE TO .....

PLACE ..... ORDER BY .....

KIND OF WORK / WORKMAN	FOREMOON		AFTERNOON		Total Hours
	Off	Off	On	Off	

Amount Sent	Amt. Ret.	Amt. Used	KIND	COST	INVOICED AT
			Oxygen		
			Acetylene — KIND		
			Filling — NAME		
			Pre-Heating		
			Cartage		
			Other Expenses		
			Hrs. Operator		
			Hrs. Helper		
			Incidentals		
Remarks			TOTALS		
			Loss or Gain		

How an Indiana welder keeps tab on costs.

example, Sir Robert Hadfield, of London, in discussing a paper by Howard J. Stagg before the Steel Treatment Research Club, of Detroit, said in part: "There is no doubt that careless and improper heat treatment, either originally by the maker or afterward by the user, is largely accountable for most of the so-called mysterious failures of boiler plate or other steel for structural purposes, and yet the existence of defects of the peculiar brittle structure are not detected by the usual tensile test." Sir Robert recommended the shock test in preference to the static test for plate and other structural steels. Mr. Armstrong recommends testing welded pressure vessels by submitting them to water pressure and subjecting the joints to a number of blows given by a hammer or by a specially designed machine that will give a uniform blow at a uniform speed, traveling along the joint at a predetermined rate. It is not at all likely that builders of such vessels particularly, and engineers generally, would submit welded tanks to such tests without protest, yet there seems to be no question in the minds of some expert metallurgists that such tests are not only much more valuable in that they tell more than the time-dignified static tests, but that the vibratory tests are sure to come into general use.—Power.

The Welding Engineer

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Copies to prospective advertisers	75
Copies to other trade papers, correspondents, etc.	60
Copies mailed as samples to prospective subscribers	825
Copies for office use	10
TOTAL	4,100

VOLUME 2. SEPTEMBER, 1917 NUMBER 9

Costs.

THE place of the cost system in a manufacturing organization should be thoroughly understood. There is no magic in cost accounting. Cost records can, by themselves, perform no miracles since, at best, they relate but the dry facts of history. Upon such history may be built a powerful campaign for increased profits, since by proper interpretation of cost results, the executive may disclose the weak spots in his organization, centers of waste, hiding holes of inefficiency, faultiness of design, significant fluctuations in operation costs, and the undesirability of individual employes.

After the War.

WHEN the business of war is closed by a world peace, the war of business will be resumed on a more gigantic scale than ever before, with greater intensity and keener competition. This is inevitable, and we must be prepared to meet it if we are to hold and extend our commanding position in the markets of the world.

Apart altogether from the conclusion of peace and the terms of that peace—when it dawns—the reflex influence of the war or American life, industry and commerce will be enormous, something not to be measured in words.

One development arising out of these war, industrial and transportation problems will be the greater spirit of co-operation which will be everywhere prevalent. Men and corporations, state and national governments, all alike, will have learned to enter into co-operative movements for greater betterment all around.

All this will be greatly needed in every department of trade, manufacture and commerce, for the simple though imperious reason that America will be confronted with the keenest trade competition from the reconstructed countries of Europe, most of which will be rivals for supremacy in the markets of the world. This is inevitable, and as certain as the rising of the sun the morning after peace is declared. We must be prepared to meet these new developments.

The Good Foreman.

A FOREMAN without lessening his dignity or self-respect or making himself too familiar with his men, will find that he cannot handle all men along the same lines. He must, therefore, adapt himself to men and their methods. He may find it trying on his patience that some men see great and imaginary difficulties surrounding their jobs; that some men are fond of making complaints, either about their working conditions or their fellow workmen; that some are easy to offend, and some wish to make themselves too friendly and effusively familiar.

It is the foreman's duty to listen to tales of troubles, make light of them, point out how small they seem, advise the workman how to get around his difficulties, smooth down the high-tempered one, so that his or the other fellow's troubles get so small and inconsequential in appearance that the workman may even apologize for thinking he had any troubles at all.

The present day requirements of a foreman have become so numerous and his duties so onerous, that he has become an asset even more than a fine machine. To get the highest efficiency out of him, he has to have some protection and encouragement to identify himself with the management.

In May, 1917, the following job welders of Minneapolis and St. Paul met and formed the Northwestern Welders Association:

Imperial Welding Company, Northern Welding Company, Twin City Welding Company, Security Welding Company, U. S. Welding Company, National Welding Company, Godfrey Welding Company, Haase Machine Works, of Minneapolis, and the Northwestern Cutting & Welding Company, of St. Paul.

All job welders of the Northwest are entitled to membership, and the St. Paul Welding Company, and Evleth Lindsay Company, both of St. Paul, have since become members of the association.

A constitution and by-laws were drawn up and adopted. The following officers were elected for one year.

President—A. W. Markley.
Vice-President—E. H. Smith.
Treasurer—L. C. Graham.
Secretary—Lorin Campbell.

Committees on membership, costs and credits were appointed, and have been actively at work in their respective lines. Meetings are held monthly, besides the regular routine impromptu talks and reminiscences of members contribute to making evenings pass quickly.

It is hoped that in the near future we will be able to include in our members practically all of the job welders in the Northwest.

The R. I. Welding Company has moved to larger quarters at 25 Bath street, Providence, R. I.

WELDING ALUMINUM

By David Baxter

The torch operator who has no experience in welding aluminum usually finds his trouble begins when he tries it. Many give up in disgust, when all that is necessary is judgment, reasonable care and a deft touch. Learn the peculiarities and humor them. Aluminum is radically different to any other metal. So we must expect the welding process to differ.

Get the job ready to weld before lighting the flame; clean and scrape the line of the weld; cut a V-shaped groove along the break; cut from both sides of the break, wherever possible, to almost the thickness of the casting. Use some precaution to prevent the heat from being carried from the weld by conduction; see if you can not strike some scheme to use, or at least prevent as much as possible, the radiation of useful heat. See that the gases are liable to be supplied steadily. Do the little things, like having the flux, filler and small tools ready. Do all these things so you won't have to stop once you get started to weld.

Preheating is more essentially a matter of care than for any other metal; greater care is necessary because aluminum melts very easily. Bring the preheating temperature up slowly and continually watch the metal. It is better not to attempt to judge the time for welding by the color of the heat. There are better ways of determining the proper time to commence welding than to trust to this judgment. In any event do not heat the metal to the welding point with the preheating fire. Just before it reaches the melting stage the metal becomes "cheesy" or crumbly; it will scrape easily with the edge of a file. We should not preheat to this temperature, as there is great danger of the metal sagging and falling in pieces.

A simple test for ascertaining the correct heat is to try at frequent intervals to light a piece of newspaper by holding it to the heating metal; if the paper takes fire we have almost reached the melting point.

Another test is by sound. Tap the heating casting with a light hammer or some other metal tool; if the sound is flat or dead it is hot enough to start welding. Cold aluminum has a clear metallic ring when struck with a metallic tool. When hot enough there is no resonance; the sound is wooden-like.

Yet another test is by appearance. Cold aluminum has a bright, smooth appearance; a reflecting, satiny surface. As it heats it gradually loses this gloss, which changes to a dull, ashen effect. When it is no longer shiny is the time to apply the flame; but do it gradually, to be doubly sure.

If the preheating is carried too far, small beads or globules, having a white, silvery look, appear upon the parts overheated. It is best not to touch the casting after it starts to bead, or sweat, as it is called. Allow the preheating fire to die gradually until the job cools appreciably, then enliven the fire slowly and watch the work carefully, again applying the tests given.

Sweating or beading sometimes appears while the torch is in use. A remedy for this will be mentioned later.

The same methods of preheating aluminum castings as have been given for other metals is employed. But remember to not have too large or rapid fire. Natural gas jets aided by a quantity of charcoal make an ideal fire, which may be covered with asbestos paper or a special preheating oven. This covering is to economize the heat that would ordinarily radiate from an open fire; the job should be on the fire when it is covered.

The reasons for preheating are identical with those of other metals, viz., to control expansion and contraction. The heat is applied in much the same manner with relation to heavy and light sections.

It is somewhat dangerous to try to localize the preheating too closely, although this can be done if everything is arranged right. It is safer, however, to aim as near as the shape and size of the job permits to heat the whole of the casting.

In attempting to confine the heat to heavy hubs, etc., let us be careful not to apply the cooling rags too suddenly or too cold; approach this part of it slowly, using warm water at first.

A fair illustration of localizing the preheating is a crank case with breaks located near the centre, from each end. Place the casting over a single gas jet or gasoline burner; this will heat an area on each side of the break sufficient to take care of the expansion, because both ends of the case are free and may push outward by the expansion. They will contract for the same reason. The area should be about eight or ten inches across if the casting is about three feet long.

Or say the case is broken toward one end; it is obvious the expansion will meet less resistance and will push outward easily. We preheat about a foot of the casting. In either instance be sure to heat the entire section; don't merely heat a spot around the weld.

A safe flame to use on aluminum is the standard neutral flame, but it is permissible and often better to use the flame having a slight excess of acetylene. This excess of acetylene reduces the heat of the flame, thereby reducing the liability of burning the metal. The low melting point of aluminum and the lower point of zinc that is usually in the composition causes this metal to be easily oxidized. Therefore the lower temperature we can use successfully the less danger we have of spoiling the metal.

In spite of the reducing flame and other precautions we often find it necessary to have a welding rod contain a higher per cent of zinc to replace that which we burn out of the casting with the flame. Zinc burns out very easily and flies away in the form of tiny white flakes.

There is no danger of carbonizing aluminum, so we may use the excess flame with little fear; this does not mean to try to weld with a large excess of acetylene. That would not produce results, because it would not melt the metals fast enough to do a clean job of welding.

On the other hand there is great danger of oxidizing aluminum. When aluminum is heated considerably beyond its fluid point it passes through a chemical change called oxidizing; it turns to a powdery substance filled with little shots of pure metal, which are exceedingly difficult to melt. This substance is called aluminum oxide; its melting point is 3000 Cent. The melting point of aluminum is much lower—approximately 650 Cent., or 1215 F. The great difference between the melting point of aluminum and its oxide, forms the chief difficulty to overcome in welding.

The remelting of the oxide or, as it is termed, alumina requires intense heat. Now when we burn or oxidize the metal in the weld we can not apply the intense heat to remelt these beads or shots, because we would ruin as much of the casting as we allowed the intense heat to

touch. The remedy is to scrape away the burned portion and insert new metal.

When you notice these little beads or shots appearing in the weld remove the flame or reduce the oxygen of the flame. Keep the flame revolving in tiny circles to the right or to the left, according to the direction of welding. Never allow the flame to remain stationary for but a moment at a time, and do not have the inner cone closer than a quarter of an inch to the weld.

On an average we choose a tip with smaller bore for aluminum of the same thickness than we do for other metal. We choose the tips according to the thickness of the section like we do for other metals, but we use slightly smaller tips, according to the thickness.

Sticks of aluminum are the only filler rods we use on aluminum. These sticks may vary in size according to the work, but nearly all of this filler material is one size—quarter-inch rods. When welding always keep the filler touching the melting weld. That is, never allow the filler metal to drip onto the weld; allow it to flow from the end into the weld. This will lessen the danger of burning the metal and prevent the heat from being wasted by conduction and radiation.

The new metal added and the molten metal of the weld should present a clear, silvery appearance under the flame. To get the idea, let us say it looks like a mirror. This bright metal blows around, in small ripples, as the flame is directed.

When once you have finished a section of the weld let it alone, even though its appearance does not please you. Do not attempt to stop welding to go back and work over the weld, but finish the job; then see what you can do for the rough spot. The best instruction we can follow is: work rapidly and deftly.

A good flux helps wonderfully in welding aluminum; it does not make the weld, but is a safeguard we should use. Sometimes it is used through a core in the welding stick; sometimes it is used by simply dipping the filler rod in the flux at intervals; sometimes it is painted along the line of welding previous to the welding operation.

We will find it almost impossible to use the flame for hot-finishing aluminum welds, although this may be done as the weld is made.

Do not try to do any hammer-finishing; in fact, no hammering at all on aluminum—it disintegrates too easily.

Reheating processes are not used on aluminum; only for the purpose of evening up the expansion and contraction.

When the weld is finished, if the job does not need reheating, cover it or bank it with asbestos paper or some other good non-conductor and allow it to cool as slowly as possible. It is not advisable to try any artificial cooling. Keep the casting covered until cold enough to lay the bare back of the hand upon.

The appearance of the weld may be enhanced by cold-finishing with files, chisels, or the emery wheel. A coat of aluminum paint lends the desired finish to set off the job.

To recapitulate: Look out for an unusually high rate of expansion and contraction; also an extremely rapid one. Remember the very low melting point and do not overheat the weld; work rapidly without hurrying and keep the flame farther from the weld; choose and use a good deoxidizing flux; and cool the finished work slowly.

After studying the salient points of the foregoing and following the steps of the process in the coming example, the novice may easily learn to weld the average aluminum job.

A Job of Aluminum Welding.

To give the novice torch operator a working knowledge of the process of welding cast aluminum, let us take for illustration a broken crank case, which is the most common job likely to come to a welding repair shop. This casting was broken by a connecting rod working loose and jamming a hole through the side of the case, also knocking one side of the flange off and losing the piece entirely.

We have to do the welding in of the hole and the building up, or replacing, the broken part of flange. The hole is about three by four inches and the section of the flange is six inches long. First we remove all grease from the section near the weld, an area of, say, six inches around. Gasoline is a splendid agent for removing the grease.

Before doing any welding we bed the job flange side up in some moist earth and carefully cut the shape of the flange out of the earth. Do this cutting so the flange cast in the impression will be thicker, or higher, than the original part. Next melt some aluminum in a babbit ladle and pour into the impression cut in the sand. Allow it to cool; when we have a piece of flange the counterpart of the lost piece. This new piece will not stick where it is poured, but may be easily fused to the crank-case with the torch, after grooving along the casting and the new piece.

Now we groove around the hole and the piece that fits it. Stick this piece in place at a point or two with the torch before preheating to hold the piece in place while welding. Do not weld a too large space; merely spot weld it. Also spot weld the piece of flange we poured.

Now, with the parts in place, we set the broken crank-case on the welding table, over a large gas burner. The break occurred in the centre section, so we place this section over the fire. Asbestos paper is covered over the job and fire. Bring the fire up gradually until the flame envelops the centre section. Test the case from time to time to prevent overheating. When the fire reaches the proper heat, take steps to prevent it from becoming any hotter; keep this heat steadily throughout the welding process.

A fair test to ascertain the proper heat is to watch the smoking casting. As soon as the smoke stops arising from the surface the welding may start. This smoke is from the burning grease, with which the casting is soaked. When the preheat has reached the proper temperature we apply the torch.

An excess or reducing flame is employed. A number six tip has been fitted to the torch; this tip has a bore of a thirty-second of an inch. A tip of this size will supply heat enough for metal of this thickness, which is three-sixteenths of an inch. As has been stated previously in this article the expansion is not retarded by the end sections, therefore we have little to fear from strains and cracks if we keep the heat equal. Also there is not much to fear from contraction until the welding is complete.

We apply the flame and the filler at the same time, always keeping the torch in motion. The filler is approximately a fourth of an inch in diameter. This is the usual size filler for all thicknesses of aluminum.

Welding in detail: Heat a space along the groove, say, two inches; apply the flame until the space is molten. At as near the same time as convenient melt enough of the filler rod to fill the groove. Now drop the filler rod and pick up the spatula or puddler. Puddle the melted metal; push and pat the melted metal a few seconds until it is mixed with the metal in the groove. Don't prolong this operation, but as soon as possible go ahead with the welding. Take up the filler and melt in another couple of inches; repeat the puddling, to connect it with the last puddle. Repeat the alternate melting and puddling and melting the full length of the groove. If any place does not show up right after it is passed do not attempt to doctor it; go ahead with the welding and fix it after the work is complete. More welds are spoiled by going back than for any other reason. Keep welding and puddling.

After welding the patch we quickly turn the casting in the fire and proceed with the flange weld. Cover awhile with asbestos to assure even heating, then weld in the

flange the same as we did the patch—by alternate melting and puddling, repeated.

On both we use flux to prevent oxidation as much as possible and to remove any oxide that happens to form in spite of us. There are some good welding compounds or fluxes on the market, but common borax is about as good as any. We apply the borax on this job by dipping the filler in it at each successive melting. That is, each time we puddle the aluminum we dip the filler rod in the flux before melting the next portion.

About the only hot finishing we can do on aluminum is that we do as the groove is being filled. Puddle and blow the molten metal in as smooth a shape as the limited time will permit.

After we have finished welding we reheat the entire section we were working on. Or, more strictly speaking, we enliven the fire a little to bring up the heat of any part that might have cooled slightly. Now we cover up the casting with an extra layer of asbestos paper, being careful that there are no holes in it to cause a draught. The casting is allowed to cool remaining on the table until cold; cold enough that it will not feel more than warm to the bare hand. The cooling may require several hours; do not hurry it.

The next step is to cold finish the job. This is accomplished with files about as handily as anything. It is quicker to use a rough wood rasp first, then use a finer file to complete the work. A coat of aluminum paint gives the last touch and covers up any defect in appearance.

TEACHING WELDERS.

To the Editor:

It seems that a wrong impression has gotten out among the welders throughout the country as to my methods of teaching, my understanding of the welding business, and my ability to train men in a short time to hold positions as competent welders.

As you probably know, we are located in the heart of the oil fields of Kansas, Oklahoma, Missouri and the Southwest, and I supply a number of the leading companies with welders.

I said in a previous article that I could make a welder in from two to four weeks, and by that I meant a welder able to set up a portable outfit, take care of apparatus, weld pipe four to sixteen inch, I-D and O-D, make overhead welds, drips, angles, bull plugs, specials and bells. I am sure my brother welders do not need to worry that any of these students will be after their jobs, as they must remember that these men are pipe line men, and that is our specialty.

I will guarantee they can weld pipe, and I teach them in from two to four weeks to do this.

There is no use in argument as to whether or not it can be done, because it is being done, and this is proved by the fact that the big employers of welders in this territory are constantly asking for more men than I can possibly supply, and those employers whom I have supplied are sending me letters of endorsement as to my methods, and I am constantly receiving letters from graduates who have taken positions in this work, and that they have made good is proved by the fact that their wages are constantly advanced.

In my school work I teach elementary chemistry, hydro carbon gases, oxygen, apparatus, prepairing and finishing, welding of different metals and pipe line welding.

I can readily see how Brother Gannon and some more of the welders misunderstood my writeup.

Here's one point we older welders must never forget. When we began to learn welding, there was nobody to teach us and we had to work out by experiment and experience every point that came up. Sometimes it would take even the best of us five and six months of study, experiment and work to establish one small point in the welding business. Now, if Brother Gannon and the other men will stop to think a minute, they can easily see how it is possible now to teach that one point to a man in a very short time.

Nowadays there are so many things about welding that are thoroughly established and clearly proven that it does not take as long to teach a man this business now as it did when we older men began to learn the trade.

These men who are here at my school are constantly learning. They put in their whole time at learning and doing the actual work in a practical way, and this accounts for the fact that they learn so very rapidly, so that a man can learn now in two or three weeks' time what it used to take months and even years of time to learn.

In those old days when we began to learn this business, every welder had his own ideas and we were, most of us, so narrow minded that we wouldn't let anybody suggest anything to us, but preferred to work everything out ourselves. All this is changed today and certain fundamental facts have been established and proved, and as a consequence, we have now a series of certain definite facts upon which to work, facts which have been proved out by actual experience and thoroughly tested, so that I am sure that my friends in the trade will agree with me that it is much easier now for any man, with the least mechanical ability, to learn welding in a short time, and not only learn it more rapidly, but learn it in a thoroughly scientific manner. This same change has come into almost every trade today.

The old time farmer used to put in about twenty years of his life learning what his boy can now learn in an agricultural college in a couple of short courses. This is true with almost every trade today, and as I said in the beginning of this article, there is no use arguing that a thing can't be done when it is being done, day in and day out, month in and month out. As the old saying goes, "The man who has said it can't be done is usually pushed aside by the man who is doing it."

W. S. Penn,
Rahe Auto School,
Kansas City, Mo.

Editor: At the risk of boring your readers, I wish to reopen the controversy in regard to the "process for cleaning non-skid tire molds and mechanical rubber molds by aid of the oxy-acetylene welding torch," which you will recall was advanced in the June issue as a recent development of the process.

Our Canadian cousin, the July issue claims, precedence for this process on the other side of the border, stating that it has been in use for some two years.

It has also been in use in the United States since early in the year 1914 at the plant of the Fisk Rubber Co., Chicopee Falls, Mass., where it was finally accepted after experiments had been made with a dozen different kinds of heating and cleaning appliances, and has been in use at the Fisk plant ever since.

A. L. Beall.

THE TIME FOR REAL CO-OPERATION.

This is the time for great forbearance, in the shop as well as out of it, and particularly in so far as it is likely to affect the production of our much needed munitions and other supplies. The tension of the times affects us all to some extent, even though we be not directly in the war zone or in the war atmosphere, and it is but natural that nerves are strung a little higher than usual.

For this very reason, we must realize that the other fellow is also under the same strain and remember that we probably annoy him as much as he does us.

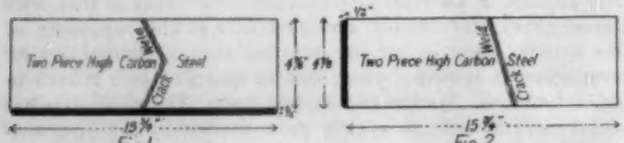
Hints for the Welder

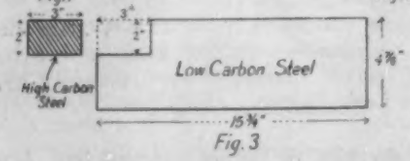
When you finish an interesting piece of work, can you set down on paper the manner in which you went about the job, how you prepared the work and how the job was done? Have you learned some little stunt every welder ought to know? Contributions to this department are paid for. Write it down any old way—I'll polish it up. Make a rough pencil sketch and our draughtsman will fix it up fine. Line drawings are more practical than photographs. Do it today—the men on the firing line are waiting.

L. B. Mackenzie, Editor.

HIGH SPEED TOOLS.

Editor: Enclosed you will find some drawings of high speed tools. I have tried to weld them together and where arrow points they crack for me. They are tools for slicing machines to cut round bar steel, and when I weld them the weld seems to be oxydized and bores also. Would you please advise me how to weld them I used Swedish iron to weld them. I preheated them before I welded them and I also welded them cold, and still they cracked for me and got very hard.





On number 3 drawing, we have a low carbon steel, and when I weld it the weld seems to be oxydized. This tool is to cut round bar steel also, for slicing machines. Could you please tell me also how to weld this tool?

Leo G. Roberts.

Answer: Bevel the edges to be welded on both sides and then build on about ⅛-inch metal on each side, previous to welding, using a ¼-inch nickel steel welding rod and a cleaning flux used for cast iron. Then let it cool for about twenty minutes. After this period properly set the parts to be welded and weld the parts together with the same rod, but without cleaning flux.

In welding the low carbon steel to high carbon steel, it is necessary to build ⅛-inch metal only on the edges of the high carbon steel. If the high carbon steel is much heavier than the low carbon steel, then preheat the low carbon steel only.

If the above instructions are followed the welds will not crack. Editor.

HARD SPOTS IN CAST IRON.

Editor: May I ask you for some information about welding heavy castings that are to be machined? I have just welded a large crank case for a mine locomotive motor weighing 1,200 pounds. On one side the holes to receive the cylinder bolts, or rather to bolt the cylinder block on, were bored wrong. This job came to me for the holes to be welded so that they may be redrilled. This was preheated with charcoal to a dark red before welding. After welding I covered with charcoal and left to cool, which took about ten hours. When this came to be re-machined it appeared to be harder than the usual casting and to have hard spots for which I cannot account, as I used a neutral flame as near as I could adjust. May I have your opinion on the matter?

D. J. Duke.

Answer: To eliminate hard spots in cast iron after welding it is necessary, in addition to the preheating process and the use of a neutral flame, to use a welding rod of good quality and which is free from manganese and containing a high percentage of silico. I would also urge the use of good clean flux. More heat must be utilized to melt cast iron than would be used for melting steel. The white jet of the blowpipe should not be allowed to come in contact with the metal, it should be held about ¼ inch from the surface. After welding allow the welded part to cool slowly and I feel sure you will not be troubed with hard spots.

Editor.

CERTIFICATES OF PROFICIENCY.

Editor: I have been a reader of your paper for some time, and have been very interested in some of your write-ups on welding experiences. I would like to give you a little of mine. If you think it is worth publishing do so, if not, there is no harm done.

I had the first custom welding shop in the United States. Helped build the first generator to be used for welding purposes, and have seen the welding business grew from its infancy; and as it grows, the more I think it is being abused. I am just going to mention a few of the instances where I think the welding business is being hurt. If I were to tell you all I have seen, it would be necessary to enlarge the "Welding Engineer" to publish it.

Now, in the first place, why should not the welding business be a trade, the same as a plumber, machinist or a blacksmith? I myself, think it is more of a trade than any of the lines mentioned, but it is not thought so by many.

A man to be a welder must be a mechanic, or he is not a welder. I have hired hundreds of men who call themselves welders, and really thought they were, but you could never make a welder out of them. Where the men of the so-called welders serve their apprenticeship in steel stamping factories, sometimes their apprenticeship runs three months, sometimes six months, when they get fired or quit. He is then out looking for a welding job, expecting to get from 45 to 60 cents an hour. All he knows about welding is one thing, and that is generally light steel stamping. They haven't the first

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W. BERKELEY, CALIF.

idea of setting up a job or finishing it, or taking care of expansion, etc.

Just a few months ago, a young man came into my shop looking for a job. I wanted a man at that time and asked him where he had been working, and what experience he had had. He said he had been taking a course at the Y. M. C. A. of this city, and that he had been there seven weeks, and had learned all he thought he could there, and would like to get a few weeks' experience in a general shop, then he was going home, somewhere in Pennsylvania, and start a welding shop there. As I talked to him, I found out that he didn't know brass from copper, or cast-iron from steel. This man will make some welder. The only job he ever had, was in his father's retail shoe store. He had no doubt read, with hundreds of others, in the "Trade Journal" about welding, and how much money can be made with the outfit, no experience needed, the instruction book furnished with the outfit, telling you all about it.

Another. I had a man working as a setter-up, we called him; that is, grinding the job and getting it ready for welding. This he could do very well, but never had a torch in his hand to do a welding job, that I know of, but he knew all about it he thought, so he told his uncle how much money there was in the welding business, and how easy it was to do. His uncle was a carpenter and had a little money, so they started in the welding business.

At this time I was welding a patent steel street car strap, and was getting 20 cents each. He knew of this job and took it at 10 cents each. Now what happened? They took the job of 3,000 hangers, of which the company had orders for about 1,500. Those were welded, finished and enameled and installed in the car, but when the passengers started to use them, they came apart. They wern't welded properly, so the steel strap company lost the order, the welding shop went broke, and the street car company paid $500 for a man falling through the window, cutting his arm and hand. So much more for the welding business. In this case the welder may never have read the instruction book.

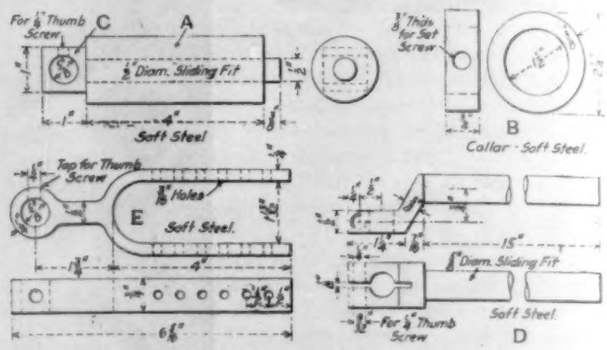
Another instance. Another man I know who was an auto repair mechanic, who had seen some welding done, but had not read the book of instructions, and he could weld, he knew he could, it was easy, so he read some of the advertisements of apparatus manufacturers, and started an auto repair and welding shop in a small town a few miles out of the city. One day a man came into the shop and said, "I see you do welding, have you one of those welding machines I see advertised that can weld everything?" Yes, sir, was the welder's reply. He said he had a broken steering knuckle on his car and asked if it could be welded. The welder said it could be done, and the man believed him at that time, but today no one could do any welding for him or his friends, as his wife is confined to a wheeling chair for the rest of her life, he had a broken collar bone, and his little girl a dislocated hip. Another book welder.

As I have seen so many, many cases of this kind, where a person's life is at stake, it looks to me as though something should be done, and the only way I can see, is for the welders to pass an inspection the same as plumbers in all cities. This would be a good thing, for all concerns, and would make a better business out of the welding, and with the large manufacturers in the welding industry, such as the Prest-O-Lite Co., Commercial Acetylene, Linde Air, Union Carbide, Air Reduction Sales Co., the Oxweld, and many other large concerns in this line, and with the help of the "Welding Engineer," should be able to bring about something that would improve the welding business, and that the welding apparatus used should be passed upon, and not allow all kinds of torches and regulators used. I believe it is a law in nearly all states where compressed acetylene and the construction of the cylinder valves and safeties, and also oxygen tanks, then why not have the rest of the equipment and the men who use it.

Standard Welding & Mfg. Co.
T. H. Mufiett.

CUTTING HOLES IN SIDE RODS WITH OXY-ACETYLENE.

A device for cutting out the holes for the crank-pin bushings in side rods is being used with success at the Silvis shops of the C. R. I. & P. A sketch of the parts is shown below. In using the device the hole for the bushings is first laid out in the usual way. A 1½-inch hole is then drilled in the center and a ¼-inch hole with the center ⅝ inch in from the edge. The bushing shown in the illustration at A is placed in the hole, being held in position by the collar B, secured by a set-screw. The swivel C is then slipped in at the bushing A and the guide D is placed through the hole in



C with the offset downward, and held in position by the set-screw in C. The fork E is placed on the end of the guide, extending upwards. The torch is set in position with the tip extending downward through the hole in the end of the guide, and clamped by a thumbscrew. The handle is supported by a pin placed through a hole in the fork E.

The guide is adjusted to cut about ⅛ inch inside the marked line, and the cut is started at the ¼-inch hole. The holes are finished as is usual on the horizontal boring machine. This device has been found to save considerable time as compared with the method of boring the holes on a drill press.—*Railway Mechanical Engineer.*

BOILER TUBES.

Editor: What are the best methods to follow in welding steam boiler tubes, to stand 250 pounds pressure?

J. L. Rollins.

Answer: Bevel both ends to 45° so as to make a butt weld. Weld about ⅛ inch on one side, then ½ inch on other side. Continue from one end of weld to other. See that weld is made throughout the thickness of tube. Use ⅛-inch Norway iron rods (or better yet, "Armco") for filler.

Editor.

CARBON BLOCKS.

Editor: Please tell me how carbon blocks are used in building up teeth in gear wheels? How can a cast-iron kettle be welded without preheating whole kettle? The crack runs about six inches down side of kettle.

H. Lambrecht.

Answer: An article on page 29 of this August issue will give you full information about the use of carbon in welding.

To weld the kettle place same on preheating fire with crack next to fire. When hot weld without moving, then allow kettle to cool slowly.

Editor.

No. 10 Foot Blower, $7.25

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For a simple, compact, portable arrangement to give a steady blast of air for blowpipe work or for any other operation requiring positive pressure air blast, we manufacture two styles and three sizes of foot blowers, ranging in capacities from three to ten cubic feet per minute. Our catalogue "BX," free for the asking, gives full description of brazing and welding appliances. **Interested?**

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"TELEGRAPH" us your orders (we never sleep).

Orders filled Day and Night

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ANNUAL MEETING OF I. A. A.

An informal meeting of the directors and other members of the association interested, called for the 3rd of August, was held as scheduled and many interesting and important matters developed for discussion.

It was decided that the annual meeting should be held this year in Chicago during October, date to be later fixed by the directors. Notice will be given members of the exact date as soon as preliminary arrangements can be made.

The meeting this year promises to be one of the most important in the history of the association, and it was the consensus of opinion that arrangements be made so that the lighting industry and the welding industry would have separate sessions for the consideration of matters of especial interest to each section, and that general meetings should be held on matters of interest to the entire association.

THE ELECTRIC WELDER IN STOVE MAKING.

The Detroit Stove Works, of Detroit, Mich., are finding it advantageous to employ electric welding machines in the manufacture of their sheet-metal stoves.

The finished product, as a direct result of this improved welding method, is more durable; and because of the smoothness of the joints the appearance of the stove is enhanced. In addition, the electric welder simplifies the manufacturing problem, as a number of small parts may be readily welded together.

Mr. H. J. Mackey, formerly sales manager for the Federal Brass Co., Chicago, has resigned to connect himself with the Decatur Brass Co., Decatur, Ill.

The Detroit headquarters of the Davis-Bournonville Co. have been moved from 88 Adams Ave. to 427 Grand River Ave. Mr. J. R. Wilson is district sales manager.

Classified Ads

Help Wanted—25c per line, minimum 4 lines.
Jobs Wanted—4 lines free.
Other Ads—50c per line, minimum 4 lines.
Count 8 words to line. Add 6 words for keyed address.

Wanted—Salesman to solicit subscriptions to *The Welding Engineer*, or furnish names of possible readers. Compensation good. Correspondence confidential. Write Mackenzie.

For Sale—Clayton Oxygen Compressor, 3 stage machine for compression up to 2,000 pounds. Displacement per minute 35 cubic feet at 150 revolutions per minute; a first-class machine in strictly fine condition for immediate shipment. Address D-140, care *The Welding Engineer*.

Wanted—Salesmen experienced in the Oxy-Acetylene business to sell first-class Welding & Cutting Apparatus and Accessories. Big opportunity for the right man. Applications will be considered confidentially. Address, C 3, care of *The Welding Engineer*.

Wanted—Experienced arc welders for New York City. Steady positions at good pay. Address A. W. Co., care *The Welding Engineer*.

For Sale—Commercial Acetylene Cylinder, 12x36, 225 cubic feet size. No more use for same. Make us a price, first-class shape. Address Cylinder, care *The Welding Engineer*.

Partner Wanted—For established welding business in large Minnesota city. Want a practical man who can design equipment, as well as weld. Small investment preferred, but not necessary. Correspondence confidential. Address Partner, care *The Welding Engineer*.

Wanted—Small second-hand generator, 25 or 50 lbs. Must be in good shape. Address Generator, care *The Welding Engineer*.

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Set the Standard in
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Our Model O. W. Outfit is designed for heavy work and will withstand the constant service that the blacksmith and boiler shop demand.

An injector type torch recognized as the most efficient and due to the exactness of construction cannot be made to backfire. Large welding jobs that are entirely out of the range of the ordinary welding outfit are successfully and easily accomplished with the AMERICAN positively non-backfiring torch.

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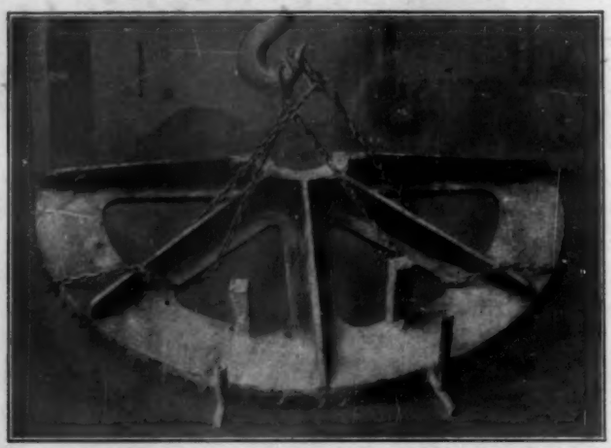
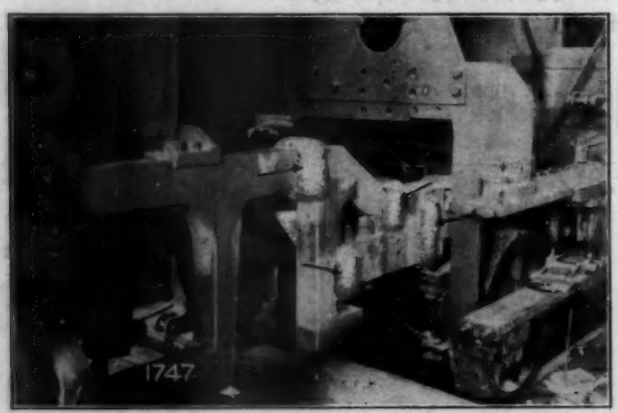
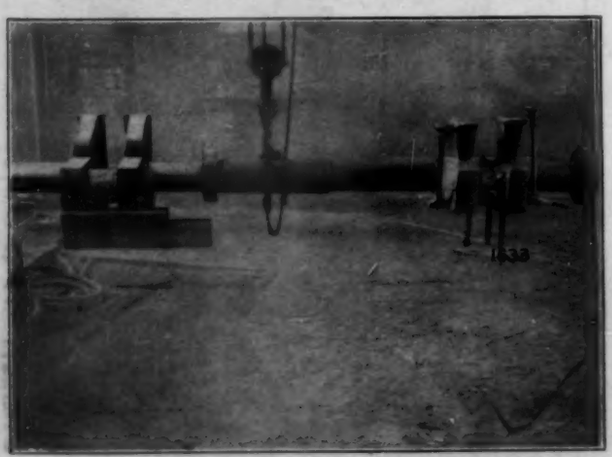


Large bevel gear on which two new teeth and crack have been repaired.



Four Thermit welds on locomotive frame on the Missouri Pacific Railroad, made without removing the frame from place.



New crank pin welded in by the Thermit Process.

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The Thermit Welding Process is the only one that is best adapted to repairing of heavy sections (see illustrations).

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wire or telephone our nearest office and we will proceed at once for arranging the shipment of materials and send an expert to supervise the repair.

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